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WHY COSTS OF MILK VARY

Possibilities of Cow Testing Associations

AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF WISCONSIN, MADISON
COOPERATING WITH THE STATE DEPARTMENT OF MARKETS

DIGEST

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Cow testing associations are a possible source of milk cost figures. Pages 4-5

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Costs per hundredweight of milk varied from $1.88 to $4.01 for different months of the year. Pages 9-10

Feed and bedding represented 54 per cent, man labor 25.8 per cent and other costs 21.2 per cent of the net cost for the year. Pages 10-12

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Why Costs of Milk Vary

P. E. McNall and D. R. Mitchell*

PROFITS IN THE PRODUCTION OF MILK depend on the difference between the cost and the selling price. The dairyman's first need is to have facts on milk costs, because his profits depend entirely on the extent to which he can produce below his selling price. Since he, individually, is practically unable to influence the price he receives, his whole effort should be directed toward the lowering of his production costs.

Any intelligent effort to reduce costs requires, first, that the costs be definitely known; and, second, that the data be complete enough to make possible a study of the factors involved. A dairyman should know definitely the influence of production on costs, the comparative economy of summer and winter feeding, and the annual and monthly distribution of costs for feed, bedding, labor, and other expenses. He should know, for his own herd and his own conditions, the unit requirements in terms of pounds of feed and bedding, and hours of labor for the production of 100 pounds of milk. In other words, he should know his own business. If he would reduce costs, he must work from facts, not guesswork.

The dairyman's first need is to have facts on milk costs. This need has been partially met by the 70 or more cow-testing associations in the state that have done and are doing splendid work. They have increased profits by getting rid of the "boarder cows" and by the feeding of "balanced rations." These associations are working in the right direction, but have not gone far enough in their record keeping to furnish the necessary cost data. The cow tester's record indicates whether a given cow pays for her feed, but does not show whether she produces at a profit or loss. This is because the tester's work is essentially a production and feed-cost study. It does not include any of the following factors which are necessary to a thorough understanding of the dairyman's problem:

*Mr. Mitchell personally conducted the field study and arranged the data. He also contributed largely to the narrative part of the bulletin.

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1. Labor costs.
2. Bedding costs.
3. Miscellaneous costs, such as building and equipment costs, including depreciation, insurance, upkeep and repairs, milk hauling, feed grinding, veterinary.
4. The unit requirements in terms of pounds of feed and bedding and hours of labor per cow and for the production of 100 pounds of milk. (The tester obtains the necessary data for determining the unit requirement for feed, but seldom uses it.)
5. Manure, calves, and miscellaneous returns to the producing herd.
6. Net profits or losses of the farm business.

It is possible to obtain more complete dairy cost figures by supplementing the work of the present cow-testing associations. Associations using a more comprehensive plan for study may be distinguished from the ordinary testing association by the term "milk-testing cost association." The tester in charge does the regular testing work and, in addition, collects the cost data from each farm, monthly. He takes the dairy inventory on each farm, notes inventory changes, figures interest, taxes, depreciation, and insurance; keeps record of feed, bedding, and labor; and, in short, keeps a complete cost record of the dairy enterprise. This results in overcoming the present inadequacy of the cow tester's record, by furnishing to the farmers facts necessary to determine their milk costs.

Whether this plan will work for any given association depends upon:

(1) **The qualifications of the tester.**

He must possess more than average ability, as he cannot hope to succeed unless he is accurate with figures and has a working knowledge of accounting principles. He must be rapid enough to carry the extra burden of work, and enthusiastic enough to complete his job.

(2) **The cooperation given the tester by the members of the association.**

They must cooperate by helping the tester in every way possible to get accurate cost data. This will usually require about one hour a month of the farmer's time. As a changing membership is undesirable, cooperators should not start the work unless they are willing to see it through.

That such a plan is workable was shown last year (Sept. 1, 1920, to Aug. 31, 1921) by the cow-testing association in the towns of Oconomowoc and Summit, in Waukesha county. Cost records were taken together with regular cow-testing work on 24 dairy farms. The results are shown in the following pages.

SEASONAL DIFFERENCES AFFECT COSTS

Many investigations have been summarized on the yearly basis with little or no attention being paid to the variations in cost from month to month. This method is not altogether satisfactory because the seasonal differences in the cost vary too much from the average yearly cost to be ignored. For example, in the work on the following pages the cost of producing 100 pounds of milk varied from 62.3 per cent of the yearly average in May to 132.8 per cent of the yearly average in November. If the average yearly cost were used as a cost fixing basis, the production of November milk would prove very unprofitable, while the production of May milk would yield a considerable return. This, of course, would tend to concentrate the production of milk in May. It is evident, if a constant supply of milk is to be maintained at all seasons, that the price paid must vary, at least approximately, with the seasonal variations in the cost of production. These monthly costs are essential to a study of this character, and are included herein with the costs for the year and for the winter and summer seasons.

The actual costs in dollars and cents are secondary to the determination of the basic requirements in pounds of feed and bedding and in hours of labor for the production of 100 pounds of milk. These costs are given only for comparison rather than for use as absolute cost figures.

BASIS OF STUDY

The producing herd was the basis of study. No record was kept of the feed and labor requirements of the young stock. Calves born during the year were credited to the herd at five days of age, and heifers freshening for the first time were charged into the herd at an estimated average value. The producing herd was considered a separate farm enterprise with the cow as the unit.

TERRITORY COVERED

The farms included in this study were in the towns of Oconomowoc and Summit, in Waukesha county. They varied in size from 56 to 320 acres, the average being 125 acres. The cows in the herds varied in number from 8 to 28, the average being 16 cows. Four of the herds were purebred, ten were part purebred and part grade, and nine were all grade. Every farm had one or more silos and, with one exception, every herd was headed by a purebred sire. Seventeen of the herds were Holstein, four were Guernsey, one was Jersey, and two were of mixed breeds. The farms varied considerably in size, breed of cattle, and system of management, but are fairly representative of the country.

METHODS OF OBTAINING DATA

The data were collected along with regular cow-testing work. The dairy accountant in charge did the testing and in addition collected the cost data from each farm each month. He was in the field during the entire time of the study and his personal knowledge of the farms was a great help in getting careful estimates of feeds consumed, bedding used, hours of labor expended, receipts, expenditures, and inventorial changes. The data were collected each month for the preceding month and entered on special forms printed for the purpose.

FORMS USED IN COLLECTION OF DATA

The forms used for entering the monthly data for each farm consisted of one for the investment, one for the income, two for the expenses, and one for the summary.*

A brief description of the method of handling the main items of expense and income follows:

I. Investment

This includes only that part of the farm investment used exclusively for the milking herd. There are four main divisions:

1. Land used for dairy buildings and yard.
2. Buildings used by the dairy herd.
3. Dairy equipment and machinery.
4. Milking herd, including the sire.

*These forms were prepared by D. H. Otis, director of the Banker-Farmer Exchange, and J. E. Stallard, former County Agent for Waukesha county. Before being used in this work, they were approved by the Department of Agricultural Economics of the University of Wisconsin.

The buildings, equipment, and machinery were inventoried conservatively on the basis of their cost minus depreciation. All grade cows were valued at $75 per head, and all purebred cows at $150 per head. Bulls were inventoried from $200 to $1,250 each, depending on their individuality and breeding.

II. Items of Expense

1. Depreciation

This is shown each month through a decrease in the inventorial valuation. Three per cent annually was figured on the buildings and silos, and 10 per cent annually on the equipment and machinery. No direct method of figuring depreciation on the cattle was used. However, if an animal was bought or sold for a sum greater or less than her inventorial valuation, the difference was figured as an income or expense. The rates of depreciation for buildings and equipment were the co-operating farmers' estimates of the usual rate for that area.

2. Taxes

The tax receipts for the preceding year were obtained and the charge to the dairy was based upon the values of that year. This charge was distributed as a monthly cost throughout the year.

3. Insurance

This charge was difficult to determine, as the majority of the farmers belonged to a town co-operative insurance company, where the losses were pro rated among the members as they occurred. Since no fixed premiums were paid, the amount charged monthly was an estimated average based upon previous annual insurance costs.

4. Interest

The interest rate used was 6 per cent per annum or ½ per cent figured monthly on the total investment at the beginning of the month. The item is handled separately so its influence on this set of records may be observed.

5. Upkeep and Repair on Buildings

The upkeep expense included painting, alterations, and minor repairs on the buildings. If the repairs materially increased the value of the buildings, they were considered improvements, and were reflected in an increase in inventory rather than an item of expense.

6. Feed (Except Pasture)

Feeds were charged each month at the average local retail price prevailing for that month. For purchased feeds, a hauling charge of 50 cents per ton mile was added, and for home-grown feeds a similar charge for hauling was deducted from the local price.

For such feeds as silage and green corn that have no quoted market valuation, the estimated farm value was used. This was $8 a ton for silage and $8 a ton for green corn. These prices are high because the corn crop fed was that grown in the summer of 1920 when all costs of growing and ensiling the crop were highest.

7. Pasture

The first plan was to determine the actual cost of pasture on the basis of acreage per cow. This plan was unsatisfactory because the cows were pastured at one time or another on practically the total farm acreage, and it was impossible to determine with any degree of accuracy the value of the gleanings from the various fields. It was finally decided to charge a uniform rate of $20 a year or $3.33 a month per head for pasture. The increase over the charge for permanent pasture is the estimated value, as given by the cooperators, of the gleanings from other fields.

8. Labor

The cost of labor is the cash paid for wages plus the estimated value of room, board and washing furnished the laborer by the operator's family. This cost averaged approximately 30 cents an hour for all hired labor. The operators' time was considered of greater value than that of the hired help. A uniform rate of 30 cents an hour was charged for hired labor, and 40 cents an hour for the operator's labor.

9. Managerial Ability and Risks

No business can long exist without intelligent management. This is especially true of dairying where the closest possible care is necessary at all times if the herd is to produce the best returns. The dairyman must be a shrewd buyer and seller of feeds and stock, a constructive breeder, a scientific feeder of balanced rations, and an executive in carrying out his plans and in the managing of his help. He must be continually on the job, as even an hour of neglect at a critical time may mean a lessening of production or even, in time, a failure of the business. This something-plus in knowledge, effort, and results, above the manual

labor of chores is "Wages of Management." It should be reflected in increased returns to the operator and is entered as a cost merely for comparison.

The dairy business, like all others, is subject to certain unavoidable risks that form a legitimate part of the costs of production. The dairyman may temporarily lose his market through the failure of his receiving plants or through strikes. At the time of the hoof-and-mouth disease, the quarantine of stock caused dairymen to lose heavily through inability to dispose of surplus animals or to purchase needed ones. As one year's records on a small number of herds will not supply the required data to determine risk items, an arbitrary charge is made. Ten per cent of all other expenses was allowed to cover risks and managerial ability.

III. Credit Items

1. Calves

All grade calves were credited to the herd at $10 each when five days of age, and all purebred calves were credited at $40 each when the same age.

2. Manure

It was assumed that a 1,000-pound cow would void 12 tons of manure a year or one ton a month. Cows of greater or less weight would void proportionate amounts. All manure was credited at $2 per ton.

3. Miscellaneous Returns

Under this heading are returns from hides, feed sacks, and insurance. It was an almost negligible quantity, amounting to $23.06 for the 24 farms during the entire year. Very few hides were sold, as the price offered did not justify the labor of skinning.

GENERAL DISTRIBUTION OF COSTS

Table I (see p. 21) is a financial statement on the per-cow basis. It shows the expenses, the credits, and the net costs per hundredweight of milk produced for the year, for the month, and for the winter and summer seasons.

The average cost per hundredweight for the year was $3.02. The variations in cost were considerable, ranging from $1.88 in May to $4.01 in November, and from $2.61 for the six summer months to $3.40 for the six winter months. The distribution of costs for the year, the summer, and the winter follows:

	Feed and Bedding	Labor	Other Costs
Year	54.0%	25.8%	20.2%
Winter	58.2%	24.7%	17.1%
Summer	48.3%	28.3%	23.4%

Feed and bedding form a larger percentage of winter costs than they do of summer costs and are the most variable of the three costs, showing a maximum variation of 9.9 per cent, while labor varies 3.6 per cent and other costs 6.3 per cent.

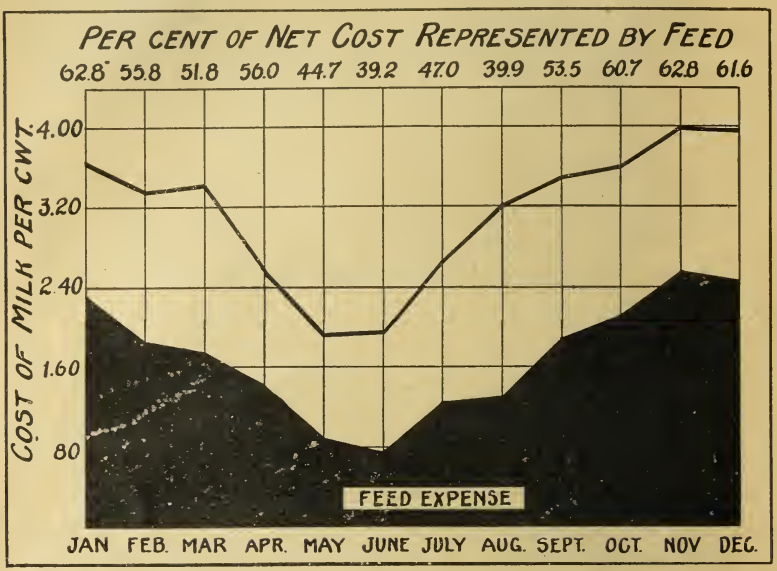

Chart No. 1—This chart shows the proportion of the net cost of producing milk represented by feed and bedding.

I. Feed and Bedding

This was by far the largest single item of expense, averaging 54 per cent of the net cost for the year. The variations from month to month are shown in Chart No. 1 and range from 39.2 per cent in June to 62.8 per cent in November. As would be expected, the feed expense for the pasture months is considerably less than for the barn-feeding months. Expressed in money terms, milk was produced 72 cents per hundredweight cheaper for feed in the summer than in the winter. As each cow produced 3,359.1 pounds of milk during the summer, this meant a difference in cost of $24.19 per cow during this period. This would appear to confirm the judgment of Wisconsin dairymen in maintaining an adequate pasture acreage, even on the high-priced lands of the southern counties. The loss in weight of cows on pasture is some offset

to this advantage, as this loss must be made up during the winter months. It is impossible to state to what extent this loss offsets the economy of pasture feeding.

II. Man Labor Expense

Labor expense is much less variable than feed. As shown in Chart No. 2, somewhat less labor is required during the summer than during the winter months. The difference is not as great as might be expected, as the time required to get the cows to and from pasture partially offsets the time saved in feeding and cleaning out the barn. The rather sharp rise in labor costs in September was due to the small volume of milk produced. The saving in labor for the pasture months amounted to 10 cents per hundred pounds of milk produced, or $3.37 per cow. Although

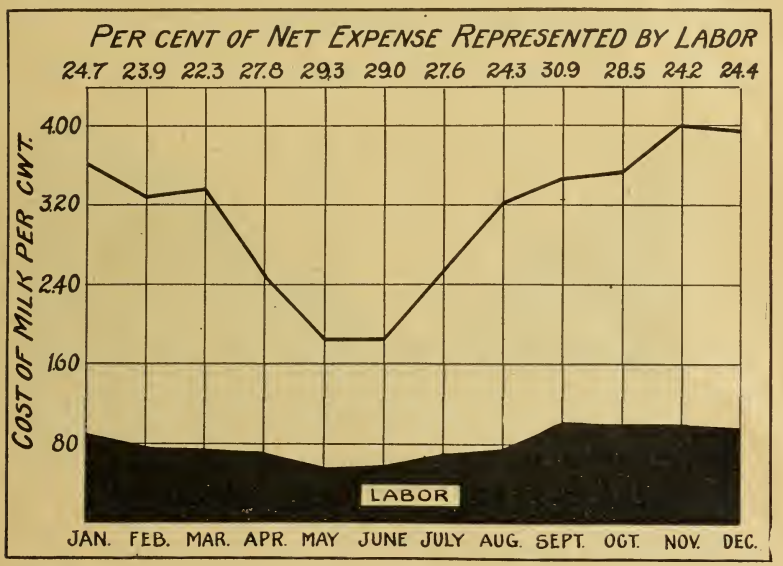

Chart No. 2—This chart shows the proportion of the net cost of producing milk represented by labor.

the saving in labor during the pasture season is not large from the money standpoint, it permits the dairyman to spend 18 hours more in the field during the summer for every milk cow kept than he could if the cows had been barn-fed the year around. With a herd of 16 milk cows this would amount to 1.6 more hours per day available for field work. As the summer is the season when the dairyman is hardest pressed for time and help, the advantage of pasture from the standpoint of labor economy is apparent.

III. Other Costs

Feed, bedding, and labor constitutes 79.8 per cent of the yearly cost, 83 per cent of the winter cost, and 76.6 per cent of the summer cost. The remainder of the expenses is composed of interest, taxes, insurance, and repairs. Variations in costs other than feed, bedding, and labor, Chart No. 3, are due to changes in credit items, or abnormally high costs of one kind or another. For example, the high cost in March was due to the loss of a $1,250 purebred Holstein bull. The high cost in August was due to a decreased milk production for that month. The low cost in October was caused by the heavy calf crop, 58 calves, or 17 per cent of

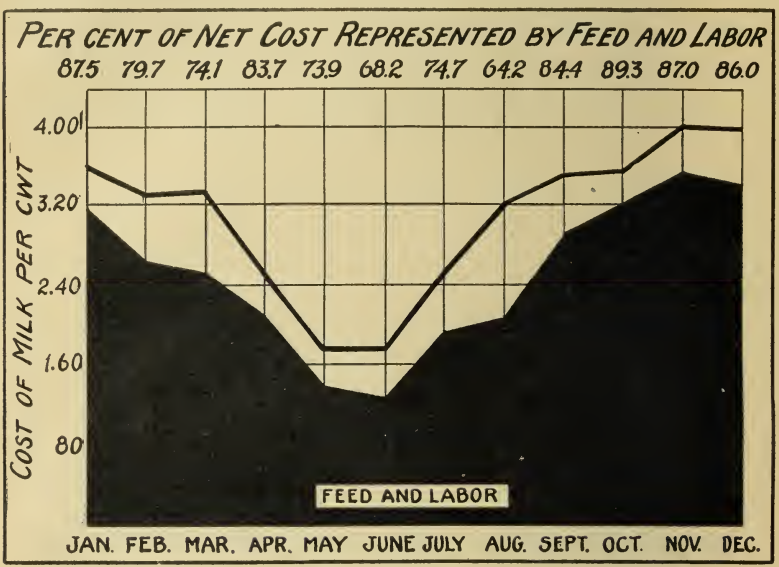

Chart No. 3. Feed and labor represents from 64 to 89% of the net cost of producing milk.

the total for the year, were born in that month. The credits for the year averaged 15 per cent of the net cost, or $32.59 per cow. Of this, $24.38 was for manure, $8.15 for net herd increase, and $.06 for miscellaneous returns.

COSTS OF KEEPING A COW

The net cost of keeping a cow for the year was $215.25 (Table I). Of this, $116.66 was for feed and bedding, $56 was for labor, and $42.59 was for other costs. The winter costs were $127.41, compared to $87.84 for the summer.

Table II (see p. 22) gives a detailed statement of the pounds of feed and bedding, hours of labor and days on pasture per cow by the year, season, and month. From this table a farmer may figure the approximate cost of keeping a cow for any given month by applying the costs for that month to the quantities listed.

A comparison of the feed required for the year, the summer, and the winter follows:

	Year	Winter	Summer	Winter Excess	Summer Excess
Concentrates	1555.2 lbs.	1073.0 lbs.	482.3 lbs.	590.7 lbs.	
Succulent roughage	8430.0 lbs.	5904.5 lbs.	2525.5 lbs.	3379.0 lbs.	
Dry roughage	2866.7 lbs.	2404.1 lbs.	462.6 lbs.	1943.5 lbs.	
Pasture	168 days	.....	168 days	.....	168 days
Bedding	883.2 lbs.	797.4 lbs.	85.8 lbs.	711.6 lbs.	
Labor	149.2 hrs.	83.6 hrs.	65.6 hrs.	18.0 hrs.	

These requirements are for a cow averaging 7,115 pounds of 3.78 per cent milk per year. The winter requirements are considerably higher than the summer requirements. The greater cost for the winter is represented by the value of the winter excess minus the value of the 168 days on pasture. For the year of this study, the difference was $38.52 in favor of summer feeding. The difference in costs other than feed, bedding, and labor was $1.05 in favor of the summer, making the net cost per cow for feed, bedding, and labor $39.57 less for the summer than for the winter period.

Minor items of cow cost are inventorial decrease, calf loss, and losses from the herd through death, sale, and other causes.

(a) Inventorial decrease

The inventorial decrease amounted to $10.95 per cow, which is 9 per cent of the average valuation of cows. The inventorial decrease added to the herd decrease or increase will give the total cow decrease or increase for the herd.

(b) Calf crop

The calf crop for the year was 84.8 per cent. The number and percentage of total dropped by months follows:

Month	Number dropped	Per cent total	Month	Number dropped	Per cent total
January	49	15%	July	6	2%
February	32	10%	August	6	2%
March	35	10%	September	28	8%
April	23	7%	October	58	17%
May	19	6%	November	45	13%
June	9	3%	December	24	7%

Total calves dropped 334
Total cows 394
Calf crop per cent 84.8

Approximately 85 calves were dropped to every 100 cows. There was a decided tendency toward winter calving, as 72 per cent of the calves were dropped in the six months October to March, inclusive. The majority of the farmers preferred fall calving, and had as many of their cows come in at that time as possible.

(c) Losses from the herd

The losses of cows from death and sales are shown below:

Means of disposal	Number	Per cent of average number in herd
Died	10	2.5%
Sold (total)	103	26.1%
For breeding	40	10.1%
To butcher	37	9.4%
Condemned for tuberculosis	24	6.1%
Slaughtered for home use	2	.5%

The total number of cows lost to the herd during the year averages 28 out of every hundred. However, the 24 condemned for tuberculosis represent an abnormal loss. If we eliminate this, the net loss to the herd would be 22 out of every hundred. Should this rate of loss continue, the cows would stay in the herd an average of about 4.5 years.

COSTS PER HUNDREDWEIGHT OF MILK

Table III (see p. 22) gives the distribution of costs and credits in the production of 100 pounds of milk. The items of cost vary greatly through the differences in cost between summer and winter feeding and through variations in the volume of milk produced. That production is one of the most important factors influencing milk cost is shown clearly in Chart No. 4. The months of high production are usually the months of low cost—the production line generally being the inverse of the cost line. In March the cost per hundredweight is greater despite increased production per cow because of the loss of a purebred bull valued at $1,250. In some years a slight increase in cost might be expected at this time because of dairymen running low on farm grains and therefore feeding proportionately larger quantities of high-priced mixed feeds, but such was not the case in this instance. Between May 1 and June 1, the cost remains practically stationary in the face of a rather sharp decrease in production. This is the period of change from barn

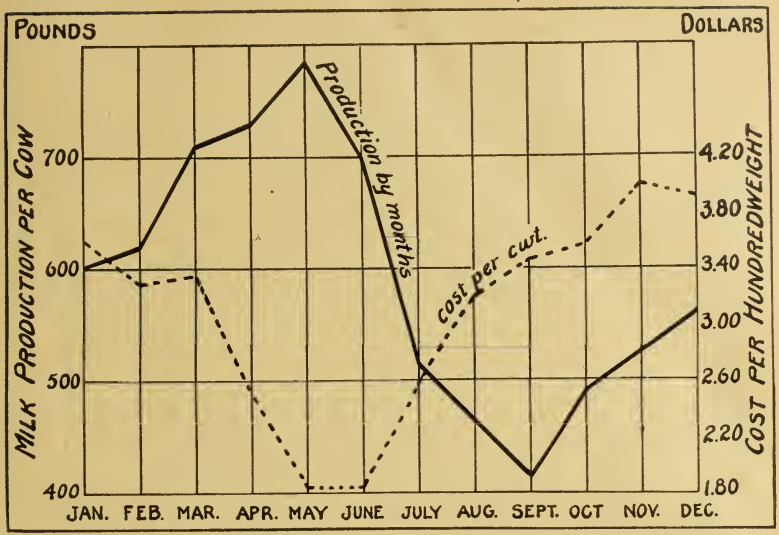

Chart No. 4—Months of high production are months of low cost per hundredweight.

feeding to pasture feeding and the shrinkage in production just about balances the decreased cost. Whether it would have paid to supplement the pasture at this point is an interesting question Personally, it is believed that the summer feeding of silage at this time can decrease the cost by maintaining the milk flow. From September 1 to November 1, the cost increases with greater production. This is the period of greatest calving, 25 per cent of the total number of calves being dropped at this time. A study of this chart will emphasize the importance, from the standpoint of the economical production of milk, of maintaining the herd at a high standard of production.

UNIT REQUIREMENTS PER HUNDRED POUNDS OF MILK

Table IV (see p. 23) gives the unit requirements in terms of pounds of feed and bedding, and hours of labor for the production of 100 pounds of milk. The yearly requirements based on the total production of 2,803,356 pounds of 3.78 per cent milk were:

Concentrates	21.9 pounds
Succulent roughage	118.5 pounds
Dry roughage	40.3 pounds
Pasture	2.4 days
Bedding	12.4 pounds
Labor	2.1 hours

Feed, bedding, and labor are 79.8 per cent of the net cost. So long as these proportions maintain, the average cost for any given year can be determined by the application of the average costs for that year to the quantities given above.

By the use of this table a dairyman can approximate his milk cost for any month of the year by applying the prices for that month to the quantities given in the table. For example, if he desires to find his March cost per hundred pounds of milk produced, he would use the quantities for March as given in Table No. 4 with the average prices prevailing for that month in his section. Assuming for the purpose of illustrating prices for this month, his March cost would be:

Concentrates	28.5 lbs. at $30 per ton	$ .43
Succulent roughage	142.0 lbs. at $ 6 per ton	.43
Dry roughage	55.7 lbs. at $20 per ton	.56
Bedding	19.1 lbs. at $ 8 per ton	.08
Labor	2.0 hrs. at 25 cents	.42
Value of feed, bedding, and labor		$1 .92
Per cent of net cost		74.1%
Net cost of March milk per hundredweight		$2.59

In using a formula of this kind it is assumed:

1. That the dairyman uses feed, bedding, and labor in about the same proportions as in the formula.

2. That his cows have an average production per year of about 7,000 pounds of milk.

3. That his feed, bedding, and labor charges bear the same proportionate relation to his net costs as in this study. Any radical difference on these points would affect the accuracy of the results.

The concentrate ration, both in kind and amount, is most likely to vary. In this study, the concentrate ration fed contained 42 per cent of the purchased feeds, mostly bran and oil meal. This proportion is the approximate requirement for a balanced ration on ordinary farms. The ratio between concentrates fed and milk production was 1 to 4.57; that is, for every pound of concentrates fed, 4.57 pounds of milk were produced. This ratio of concentrates to milk is normal for all but forced feeding, a method not practiced on most farms. The average production of the 24 herds, namely, 7,115 pounds, is almost identical with the average production for the cow-testing associations in the state. To assume that the ratio of feed, bedding, and labor requirements to the net cost, which has been worked out for these farms, holds for all farms would

be to assume that the costs, other than feed and labor, would vary from time to time to the same degree as the costs for feed, bedding, and labor. That is, if the charges for feed, bedding, and labor decreased one-half, other costs would decrease one-half also. Because most of the fixed or less changeable items of cost are included in "Other Costs" an increase in feed and labor cost will tend to decrease the relative value of the "other costs" items. Likewise a decrease in the value of the feed or labor items will tend to increase the relative value of the "other costs" items.

If cost formulae are used with an intelligent understanding of their limitations, they are a great aid to the farmer in finding his approximate milk costs.

Table V (see p. 24) gives a grouping of the herds according to the cost per hundred pounds. It will be noticed that 63.8 per cent of the milk was produced at average cost or less. Theoretically, if the price paid for milk were based on its average cost, only two-thirds of the supply would be available, because farmers would refuse to produce at a loss. With the decrease in supply would come an increase in the price offered. This would stimulate production and make it possible for some, whose previous costs had been above the average, to now produce milk at a profit. The final adjustment would probably find the price somewhere between the average and the maximum cost. This statement presupposes: (1) That the farmers know their costs; and (2) that knowing them they would refuse to produce at a loss. Neither of these suppositions is entirely true. Probably the greater part of the milk reaching the market is produced by dairymen who have little or no idea of what it costs them. If dairymen did know their costs and were compelled for any considerable period to accept less, the majority would probably go out of the dairy business, or, at least, reduce their dairy operations. There are a few dairymen, however, who probably would continue to produce at a loss because they could do no better at any other work.

INFLUENCE OF PRODUCTION ON MILK COSTS

This subject has already been discussed in a general way from the standpoint of the average cow and the average cost. Production was found to be the greatest factor influencing costs, the months of high production being the months of low cost and vice versa, both for the individual cow and for the herd. Can we

infer from this that the cow producing 8,000 pounds will do so at a lower cost per hundredweight than will a cow producing 6,000 pounds? In other words, how do cows of varying production influence milk costs?

In an attempt to throw some light on this question the 24 herds were arranged in the order of their average milk production per cow. The herds were then divided into three equal groups called Group I, Group II, and Group III. Group I contained the 8 herds of lowest average production, Group II the herds of medium productoin, and Group III the herds of highest average production per cow. A detailed study from the standpoint of relative economy was then made, the results of which are shown in the following tables.

The average production of each of the lots is shown in Table VI (see p. 24). Group I averaged 5,554 pounds, Group II, 7,130 pounds, and Group III, 8,622 pounds. The difference between each group is about 1,500 pounds.

The requirements per cow for the various groups, Table VII (see p. 24) show that in general the roughage requirements were about the same. The concentrate requirements were proportional to the milk yield. In other words, the higher producing cows did not get any more silage and hay than did the low producing ones, but did obtain a more liberal feeding of the grain ration. The pasture days, pounds of bedding, and hours of labor show no very significant variations, as these factors are largely independent of production.

When the yearly requirements for these groups are reduced to the requirements for 100 pounds of milk, however, very significant variations are noted, the higher producing cows showing marked economy in all items except concentrates. Table VIII (see p. 24) shows that the requirements per hundred pounds of milk for cows in Group III are less than those in Group I by the following amounts: 3.6 pounds of concentrates, 28.6 pounds of silage, 26.4 pounds of hay, 1.2 pasture days, 4.8 pounds of bedding, and .7 hours of labor. The ratio of concentrates to milk produced varies but slightly for the different groups. The ratio was 1 to 4.06 for Group I and 1 to 4.76 for Group III. The total difference in cost of feed, bedding, and labor, using average prices for the year, amounted to 88 cents per hundred pounds. There was also a difference in "other costs" in favor of Group III of 30 cents, making the total dif-

ference between the highest producing and the lowest producing group $1.18 per hundred—a considerable saving. Group II produced milk 81 cents per hundred cheaper than Group I.

These results are as should be expected, because most of the expenses of milk production are as large for the low as for the high producing cows. It takes as good a barn to house one as the other, just as much labor, bedding, days on pasture, and almost as much for other costs. The economy of the higher producer lies in the fact that this expense is divided into a larger volume of milk, making the cost per hundred pounds less.

The economy of milk production, then, lies largely in the production of the individual cow. This fact should emphasize the prime importance of breeding, selecting and testing for production, and for the vigorous weeding out of all cows unable to meet a fair production requirement.

QUANTITY OF GRAIN TO FEED

The quantity of grain in the ration is closely related to any discussion of production. If production is the largest factor of milk costs, to what extent will it pay a dairyman to feed for production? How much grain should he feed, and will forced feeding pay? Cost figures obtained by milk-testing cost associations will aid the dairyman in answering these questions by making possible a comparison of his own unit requirements with those of the average for his neighborhood.

From Table VII it is seen that Group III's grain requirement per cow is 318 pounds greater and that its cow cost is $13.30 greater than are those of Group II. Did the heavier feeding pay?

Table VIII, which is Table VII reduced to the one hundred pound basis, shows that Group III, in spite of heavier feeding and added costs per cow, produced milk cheaper by 37 cents a hundredweight than did Group II. This was made possible by his increased production that effected economies in all cost items except concentrates. The heavier feeding of grain was justified in this case because of decreased cost per hundredweight of milk produced.

Will it pay Group III to feed still heavier? This will depend on the degree to which these cows will respond to extra feed, and also to the existing production costs for feed, labor, and other items. The only method of determining this is by experimenting,

and interpreting results from milk cost data. From Table VIII we find that Group III's grain requirement per hundred pounds of milk is almost the same as Group II. In other words, Group III gave proportionately as much milk for grain fed as did Group II and therefore so long as any added grain will yield the same proportionate increase in milk, the extra feeding will pay. This is clear, because each increase would add nothing to Group III's grain cost per hundredweight of milk and would mean increased economies in all other cost items. As long as Group III can obtain proportionate increases in milk, this group is decreasing its production costs.

The next question is, to what extent will it pay to feed beyond this point? It is true that as soon as added grain brings diminishing returns in milk, the grain requirement per hundred pounds of milk will increase and will add to the production costs. But it is true also that for every increase in milk flow resulting from the heavier feeding, there will be savings in all other costs. These economies will make it profitable to feed somewhat past the beginning of diminishing returns for grain. The concentrate ration could profitably be increased to that point where the cost of the last increase of grain would just equal the saving on the fixed charges such as roughage, labor, and housing due to the increased milk flow. To feed more would be to increase costs.

TABLE I —DISTRIBUTION OF COSTS PER COW.

(SIX WINTER OR BARN-FEEDING MONTHS.)

	Yearly	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Winter Months
Production	pounds	pounds	pounds	pounds	pounds	pounds	pounds	pounds
Milk	7115.2	521.7	556.9	601.4	620.4	710.6	732.3	3746.0
Fat	268.7	19.9	21.2	23.1	23.9	26.9	26.7	141.7
Test, per cent	3.78	3.82	3.80	3.85	3.85	3.79	3.64	3.78
Items of expense								
Feed and bedding	$116.66	$ 13.15	$ 13.45	$ 13.68	$ 11.43	$ 12.38	$ 10.27	$ 74.35
Labor	56.00	5.10	5.37	5.41	4.89	5.34	5.14	31.24
Interest	21.12	1.79	1.69	1.78	1.77	1.77	1.76	10.56
Taxes, insurance, repairs.	4.79	.34	.39	.30	.30	.31	.30	1.94
Net herd decrease	.....	.....	.....	.....	.....	1.24	.....	.....
Bldgs. and equip. depreciation	5.09	.30	.47	.73	.....	.76	.74	2.05
Miscellaneous	17.14	1.53	1.50	1.19	2.83	1.28	1.33	9.66
Managerial wage, risks, etc	27.04	2.53	2.70	2.96	2.57	2.85	2.29	15.90
Total	$247.84	$ 24.74	$ 25.57	$ 26.05	$ 23.79	$ 25.93	$ 21.83	$145.70
Returns not milk								
Net increase	$ 8.15	$ 1.69	$ 1.60	$ 2.20	$ .26	.....	$ 1.33	$ 5.83
Miscellaneous	.06	.....	.02	.....	.....	.....	.....	.04
Manure	24.38	2.13	2.05	2.09	2.07	2.05	2.05	12.42
Bldgs. and equip. appreciation	.....	.....	.....	.....	.96	.....	.....	.....
Total	$ 32.59	$ 3.82	$ 3.67	$ 4.29	$ 3.29	$ 2.05	$ 3.38	$ 18.29
Net cost	$215.25	$ 20.92	$ 21.90	$ 21.76	$ 20.50	$ 23.88	$ 18.45	$127.41
Net cost of milk per cwt	3.02	4.01	3.93	3.60	3.30	3.36	2.52	3.40
Net cost of butterfat per lb	.80	1.05	1.03	.94	.83	.89	.69	.90

(SIX SUMMER OR PASTURE-FEEDING MONTHS)

	May	June	July	Aug.	Sept.	Oct.	Summe Months
Production	pounds	pounds	pounds	pounds	pounds	pounds	pounds
Milk	784.3	699.9	516.1	464.3	412.8	491.7	3369.1
Fat	29.0	26.0	19.2	17.7	16.4	18.8	127.0
Test, percent	3.69	3.71	3.72	3.80	3.97	3.83	3.77
Items of expense							
Feed and bedding	$ 6.78	$ 5.20	$ 6.22	$ 5.89	$ 7.66	$ 10.58	$ 42.31
Labor	4.26	3.81	3.64	3.64	4.43	4.98	24.76
Interest	1.76	1.75	1.73	1.73	1.79	1.80	10.56
Taxes, insurance, repairs	.55	.31	.62	.30	.73	.33	2.85
Net herd decrease	.....	.49	.....	1.97	.....	.....	.....
Bldgs. and equip. depreciation	.75	.59	.49	.74	.....	.61	3.04
Miscellaneous	1.36	1.32	.94	.87	1.68	1.32	7.48
Managerial wage, risks, etc	1.92	1.72	1.64	1.66	1.93	2.26	11.14
Total	$ 17.38	$ 15.19	$ 15.28	$ 16.80	$ 18.22	$ 21.88	$102.14
Returns not milk							
Net increase	$ .56	.....	$ .11	.....	$ 1.72	$ 2.40	$ 2.32
Miscellaneous	.....	.....	.....	.....	.....	.02	.02
Manure	2.04	$ 1.95	1.93	$ 1.90	2.05	2.08	11.96
Bldgs. and equip. appreciation	.....	.....	.....	.....	.15	.....	.....
Total	$ 2.60	$ 1.95	$ 2.04	$ 1.90	$ 3.92	$ 4.50	$ 14.30
Net cost	$ 14.78	$ 13.24	$ 13.24	$ 14.90	$ 14.30	$ 17.38	$ 87.84
Net cost of milk per cwt	1.88	1.89	2.57	3.21	3.46	3.54	2.61
Net cost of butterfat per lb	.51	.51	.69	.84	.87	.92	.69

TABLE II—FEED AND LABOR REQUIREMENTS PER COW

(SIX WINTER OR BARN-FEEDING MONTHS)

	Yearly	Nov.	Dec.	Jan.	Feb.	March	April	Winter Months
Concentrates, lbs.	1555.2	148.0	170.3	181.6	171.3	202.4	199.3	1073.0
Succulent roughage, lbs.	8430.0	946.8	998.2	1023.9	983.9	1009.0	942.7	5904.5
Dry roughage, lbs.	2866.7	399.0	455.2	430.5	356.8	395.5	367.1	2404.1
Pasture, days	168	.....	.....	.....	.....	.....	.....	.....
Bedding, lbs.	883.2	103.7	133.6	157.0	135.8	135.6	131.7	797.4
Labor, hours	149.2	13.5	14.2	14.5	13.1	14.4	13.9	83.6
Per cent of net cost	79.8	87.0	86.0	87.5	79.7	74.1	83.7	82.9

(SIX SUMMER OR PASTURE-FEEDING MONTHS)

	May	June	July	Aug.	Sept.	Oct.	Summer Months
Concentrates, lbs.	126.0	65.4	54.6	55.1	59.8	121.4	482.3
Succulent roughage, lbs.	438.1	189.7	416.1	388.7	451.4	641.5	2525.5
Dry roughage, lbs.	140.1	46.7	55.4	52.7	45.3	122.4	462.6
Pasture, days	17.0	30.0	31.0	31.0	30.0	29.0	168.0
Bedding, lbs.	57.2	11.7	8.4	8.5	.....	.....	85.8
Labor, hours	11.5	10.2	9.8	9.7	11.4	13.0	65.6
Per cent of net cost	73.9	68.2	74.7	64.2	84.4	89.3	76.6

TABLE III—DISTRIBUTION OF COSTS PER HUNDREDWEIGHT OF MILK

(SIX SUMMER OR PASTURE-FEEDING MONTHS)

	May	June	July	Aug.	Sept.	Oct.	Summer Months
Items of expense							
Feed and bedding	$ .84	$ .74	$ 1.21	$ 1.28	$ 1.85	$ 2.15	$ 1.26
Labor	.55	.55	.71	.78	1.07	1.01	.74
Interest	.22	.25	.33	.37	.43	.37	.31
Taxes, insurance, repairs	.07	.04	.12	.06	.18	.07	.08
Net herd decrease	.....	.07	.....	.43	.....	.....	.....
Bldgs. and equip. depreciation	.10	.08	.10	.16	.....	.12	.09
Miscellaneous	.17	.19	.18	.19	.41	.27	.22
Managerial wage, risks, etc.	.24	.25	.32	.35	.47	.46	.33
Total	$ 2.21	$ 2.17	$ 2.97	$ 3.62	$ 4.41	$ 4.45	$ 3.03
Returns not milk							
Net herd increase	$ .07	.....	$ .02	.....	$ .41	$ .49	$ .07
Miscellaneous	.....	.....	.....	.....	.....	.....	.....
Manure	.26	.28	.38	.41	.50	.42	.35
Bldgs. and equip. appreciation	.....	.....	.....	.....	.04	.....	.....
Total	.33	.28	.40	.41	.95	.91	.42
Net cost of milk per cwt.	$ 1.88	$ 1.89	$ 2.57	$ 3.21	$ 3.46	$ 3.54	$ 2.61

TABLE III—SIX WINTER OR BARN-FEEDING MONTHS

	Yearly	Nov.	Dec.	Jan.	Feb.	March	April	Winter Months
Items of expense								
Feed and bedding	1.63 $	2.52 $	2.42 $	2.26 $	1.84 $	1.74 $	1.41 $	1.98 $
Labor	.78	.97	.96	.89	.79	.75	.70	.84
Interest	.30	.34	.30	.29	.28	.25	.24	.28
Taxes, insurance, repairs.	.07	.06	.07	.05	.05	.04	.04	.05
Net herd decrease	.....	.....	.....	.....	.....	.17	.....	.....
Bldgs. and equip. depreciation	.07	.06	.08	.12	.....	.11	.10	.06
Miscellaneous	.24	.30	.28	.20	.46	.18	.18	.26
Managerial wage, risks, etc	.38	.49	.48	.49	.41	.40	.31	.42
Total	$ 3.47	$ 4.74	$ 4.59	$ 4.30	$ 3.83	$ 3.64	$ 2.98	$ 3.89
Returns not milk								
Net herd increase	$ .11	$ .32	$ .29	$ .36	$ .04	.....	$ .18	$ .16
Miscellaneous	.....	.....	.....	.....	.....	.....	.....	.....
Manure	.34	.41	.37	.34	.34	.28	.28	.33
Bldgs. and equip. appreciation	.....	.....	.....	.....	.15	.....	.....	.....
Total	$ .45	$ .73	$ .66	$ .70	$ .53	$ .28	$ .46	$ .49
Net cost of milk per cwt.	$ 3.02	$ 4.01	$ 3.93	$ 3.60	$ 3.30	$ 3.36	$ 2.52	$ 3.40

TABLE IV—FEED AND LABOR REQUIREMENTS PER HUNDREDWEIGHT OF MILK

(SIX WINTER OR BARN-FEEDING MONTHS)

	Yearly	Nov.	Dec.	Jan.	Feb.	March	April	Winter Months
Concentrates, lbs.	21.9	28.4	30.6	30.1	27.6	28.5	27.2	28.6
Succulent roughage, lbs.	118.5	181.5	179.2	169.5	158.6	142.0	128.7	157.6
Dry roughage, lbs.	40.3	76.5	81.7	71.3	57.5	55.7	50.2	64.2
Pasture, days	2.4	.....	.....	.....	.....	.....	.....	.....
Bedding, lbs.	12.4	19.9	24.0	26.0	21.9	19.1	18.0	21.3
Labor, hours	2.1	2.6	2.6	2.4	2.1	2.0	1.9	2.2
Per cent of net cost	79.8	87.0	86.0	87.5	79.7	74.1	83.7	82.9

(SIX SUMMER OR PASTURE-FEEDING MONTHS)

	May	June	July	Aug.	Sept.	Oct.	Summer Months
Concentrates, lbs.	16.1	9.3	10.6	11.9	14.5	24.7	14.3
Succulent roughage, lbs.	55.8	27.1	80.6	83.7	109.3	130.5	75.0
Dry roughage, lbs.	17.9	6.7	10.7	11.3	11.0	24.9	13.7
Pasture, days	2.4	4.1	5.6	6.2	7.6	6.6	5.0
Bedding, lbs.	7.3	1.7	1.6	1.8	.....	.....	2.6
Labor, hours	1.5	1.5	1.9	2.1	2.2	2.6	2.0
Per cent of net cost	73.9	68.2	74.7	64.2	84.4	89.3	76.6

TABLE V—RANGE IN COSTS PER HUNDREDWEIGHT OF MILK

Cost per 100 lbs.	Quantity produced at given cost	Percentage of total production	Cumulative percentage
	Pounds	Per cent	Per cent
$2.19	208,847	7.45	7.45
2.33	133,360	4.76	12.21
2.39	136,198	4.86	17.07
2.49	195,658	6.98	24.05
2.53	88,930	3.17	27.22
2.72	227,774	8.13	35.35
2.81	115,698	4.13	39.48
2.91	114,806	4.10	43.58
2.92	103,136	3.68	47.26
2.97	150,784	5.38	52.64
2.99	139,450	4.97	57.61
*3.02	173,792	6.20	63.81
3.06	125,412	4.47	68.28
3.11	160,221	5.72	74.00
3.49	117,488	4.19	78.19
3.53	107,652	3.84	82.03
3.57	85,799	3.06	85.09
3.83	72,464	2.59	87.68
3.95	88,115	3.14	90.82
4.03	56,338	2.01	92.83
4.04	67,444	2.41	95.24
4.24	76,674	2.74	97.98
4.67	57,316	2.02	100.00

* Average cost of milk per hundredweight.

TABLE VI—PRODUCTION STATEMENT OF HERDS

	Number of herds	Average size of farms	Average no. cows per farm	Average production milk	Average production fat	Average test percentage
		Acres		Pounds	Pounds	Per cent
GROUP I	8	153	15.4	5554.	225.5	4.06
GROUP II	8	125	18.1	7130.	268.1	3.76
GROUP III	8	99	15.8	8622.	312.1	3.62

TABLE VII—YEARLY FEED AND LABOR REQUIREMENTS PER COW

	Concentrates	Succulent roughage	Dry roughage	Pasture	Bedding	Man labor	Total costs per cow
	Pounds	Pounds	Pounds	Days	Pounds	Hours	
GROUP I	1,367	7,333	3,229	174	846	144	$204.06
GROUP II	1,493	8,936	2,662	163	899	143	214.13
GROUP III	1,811	8,918	2,740	169	901	163	227.43

TABLE VIII—FEED AND LABOR REQUIREMENTS PER HUNDREDWEIGHT OF MILK

	Concentrates	Succulent roughage	Dry roughage	Pasture	Bedding	Man labor	Cost per 100 lbs. milk
	Pounds	Pounds	Pounds	Days	Pounds	Hours	
GROUP I	24.6	132.0	58.1	3.1	15.2	2.6	$3.82
GROUP II	21.0	125.3	37.4	2.3	12.6	2.0	3.01
GROUP III	21.0	103.4	31.8	2.0	10.4	1.9	2.64

W75b

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MAR 9

Marketing by Cooperative Sales Companies

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Success in the cooperative marketing movement depends upon rendering better service at lower cost. Pages 4-6

Cooperation does not guarantee making profits. Efficiency must be developed by a cooperative system if profits are to be secured. Pages 5-6

Better service in storing and distributing cheese is needed to stabilize prices in order to reduce hazards of cheese production. Pages 7-8, 20-21

Price fluctuation is largely caused by the universal practice of farmers in dumping their products on the market without regard for the demand. Page 9

The marketing margin received by cheese dealers has been reduced more than one-half by cooperative effort. Pages 10-11, 26-27

Volume of business is necessary for a Cheese Federation to render storing services that will stabilize prices. Page 13

Paying the best cheesemakers more and giving them larger volume of milk reduces cost of making cheese and improves the price. This must be accompanied by doing away with small factories and poor makers. Pages 16-18

The cheesemaker is not a salesman and cannot do this work properly whether trained or not. His time is too short and he has not enough cheese to sell. Pages 18-19

Cheese Boards cannot solve cheese marketing problems because they cannot enable farmers to wait until the proper time of selling to dispose of their output. Page 20

The service of district exchanges is essential to permit farmers to hold their cheese until the right time to sell. The district warehouse is necessary to handle cheese least expensively. Pages 21-23

District groups of cheese factories cannot sell cheese to advantage. They have too small a volume of cheese to do this task well. Pages 23-24

Best merchandising of cheese requires a national cheese sales organization. Many district groups must join in order to provide sufficient business to make it worth while. Pages 24-25

The greatest results to be gained by cooperative cheese marketing, namely, improved marketing service, are still ahead. Page 27

Volume of business is the foundation for the development of the best service and hence the largest benefits of cooperative effort. Page 29

Marketing by Cooperative Sales Companies

Theodore Macklin

THE GREATEST improvements in marketing during recent years have come through the establishment and operation of sales companies doing their work with minimum expense and rendering better service than was previously available.

Although Wisconsin is noted for the development of co-operative enterprises by farmers, mostly of a local character, as shown by creameries, cheese factories, livestock shipping associations and similar enterprises, yet not until recently has the state accomplished much in real cooperative sales organizations. While the attention of farmers has been called repeatedly to the cooperative marketing companies of California, Canada and other countries, few people in the state have realized that within her borders there were at least two important enterprises—The Wisconsin Cheese Producers' Federation and The Wisconsin Cranberry Sales Company—worthy of the name of cooperative sales companies.

Wisconsin cheese has been successfully marketed cooperatively more than eight years, and cranberries for a longer time. This definitely shows that Wisconsin farmers who wish to co-operate may successfully do so if they earnestly and persistently follow sound plans. Numerous farmers are determined to bring about better conditions in marketing by means of cooperation. It is timely to inquire what these farmers believe cooperation is able to accomplish in marketing and under what conditions it bids fair to meet their expectations. As an example that will be most widely understood, take the cheese industry. What do cheese producers expect to gain by cooperation in marketing their product and what must be done to gain success? What may be wise in marketing cheese cooperatively may be equally advisable for those interested in marketing butter, tobacco, livestock, or other farm products.

Possibility for Cooperation

Cooperation enables a group of farmers to assume responsibility for having their products marketed. In other words, it enables a group to employ management, other workers and equipment needed for doing the work of delivering products, which are on the farm today in the shape of raw materials, to the consumer tomorrow in the form of finished articles that consumers can use. This work, in the absence of cooperative marketing companies, is accomplished by private marketing companies.

It so happens that most of the marketing work of the present day is done by private companies and not by cooperatives. The

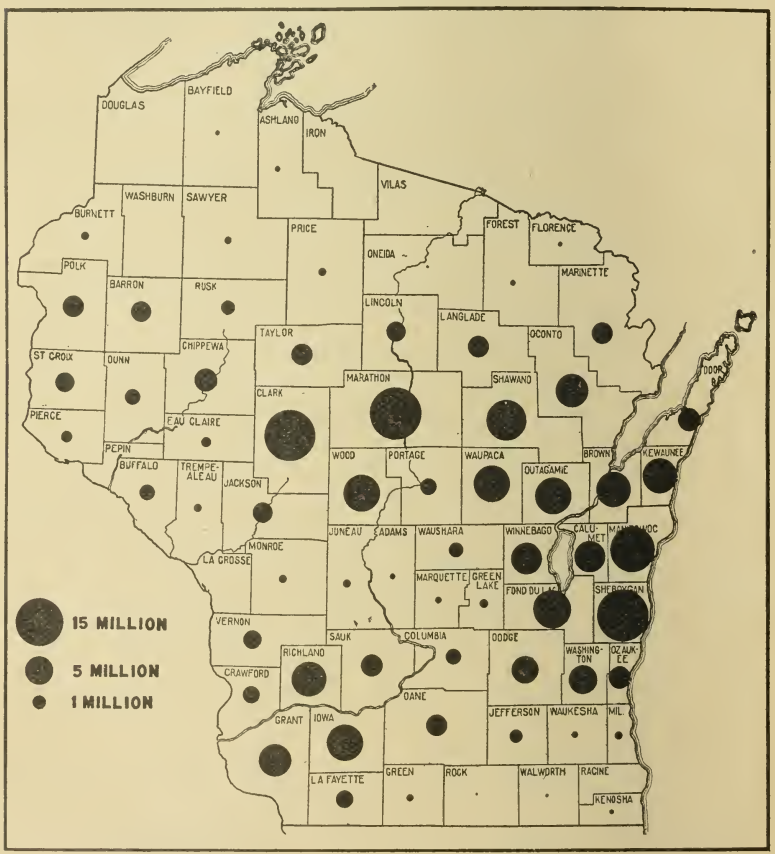

FIG. 1.—WISCONSIN'S OUTPUT OF AMERICAN CHEESE

More than 235,000,000 pounds of American cheese and almost 70,000,000 pounds of brick, swiss and limburger cheese were produced in the state during 1919. Cheese is a leading Wisconsin product and its marketing should be the most efficient possible.

reason is that individuals have organized private corporations, partnerships or individual enterprises, supported these concerns with their financial resources and personal services and then have gone out after business. This has meant the securing of cheese in one way or another from cheese factories and from other dealers. Once they had the cheese their next problem was to dispose of it advantageously. This meant that the cheese had to be moved from the factory to that state or city in which consumers would pay the most satisfactory prices during the year.

Marketing Causes Expense

It not only costs money to send cheese from Wisconsin to all of the various states, but moreover, it takes a vast amount of accurate information coupled with keen judgment to be sure that in sending a carload of cheese to Tampa, Florida, better results would not have been obtained by sending it to Los Angeles, California. To employ salesmanship that may be relied upon to dispose of cheese to advantage is expensive. Furthermore, to assemble cheese at a central plant from numerous local cheese factories so that it may be paraffined, graded, branded, stored if necessary, loaded into cars and sent on its way to 48 states also involves the purchase of supplies, the hiring of labor and the rental of warehouses and cold storages. All this results in further expense. No middleman who ignores the question of so controlling expenses of all kinds as to get the most work done for the least money is likely to be successful.

The work of cheese marketing, therefore, is to secure a volume of business, operate the business at the lowest possible expense per pound, and sell the goods at the best prices obtainable. In these particulars the cooperative marketing company does not differ at all from the private. The work of marketing is fundamentally the same whether the farmer, a private middleman, or a cooperative middleman or the consumer does it. The important questions are whether better service is realized one way or another, whether it costs more to do it one way or another, and whether the profits gained by doing the work of marketing efficiently go to the farmer or to someone else.

Does Cooperation Insure Profits?

The mere change of a private into a co-operative business by no means insures that profits will be made. All that cooperation guarantees is that if the work of marketing is efficiently done

and if profits are thereby earned, these profits will go to the farmer cooperators who now own the business instead of as formerly to one or more non-farmer middlemen who formerly owned the business. The most important questions are: (1) How may the cooperative marketing company render better service than the private company, and (2) How may the cooperative marketing company operate with lower expenses than the private company. If these two great objects are attained then only has cooperation met the full hopes of the cooperators. If cooperation does not achieve these purposes then it has made no financial improvements over the private marketing concern.

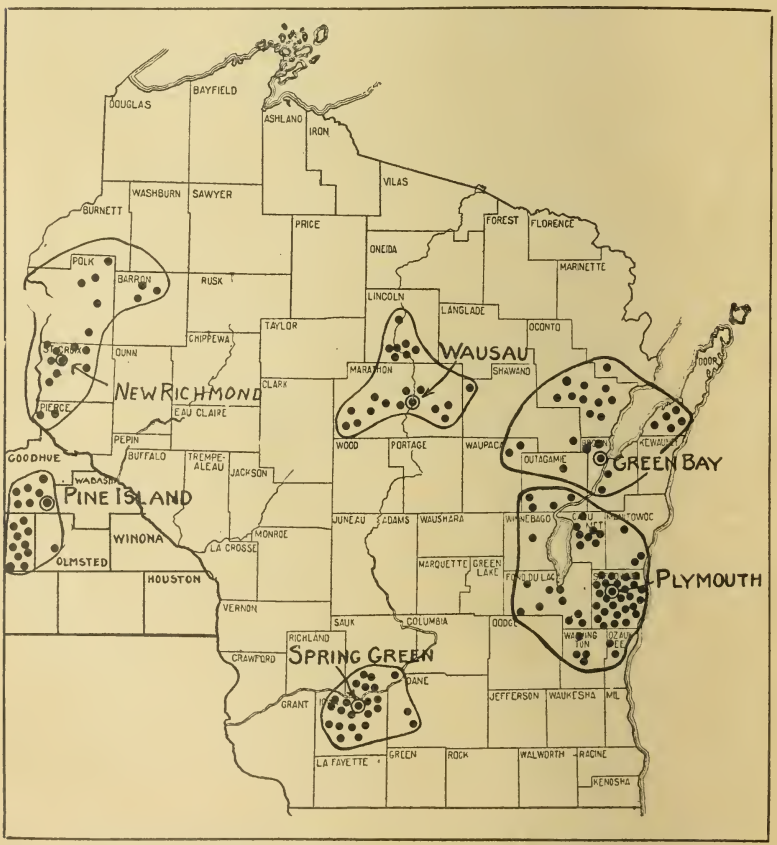

FIG. 2.—LOCATION OF COOPERATIVE CHEESE MARKETING SYSTEM

Local cheese factories, numbering 168 shown by the black dots and organized into district groups each surrounding a warehouse form the federation which supports the sales company known as the Wisconsin Cheese Producers Federation. (See Figs. 3 and 5.)

Need for Better Service

Without thoroughly examining all causes for their predicament cheese producers generally affirm that one of their greatest hardships is caused by the fluctuation in cheese prices. They reason this way: if the price of cheese is 18 cents a pound then wise plans for production justify the development of a herd of a certain number, say, ten cows. This, in order to care for the herd properly, requires a certain quantity of feed and of labor at given prices. Assuming that the income from this herd will be a given figure because cheese is 18 cents a pound, then they can afford to pay a given price for the needed feed and labor. After making plans on this basis, however, the seasonal decline in price upsets all reasonable calculations and changes the paper profit to an actual loss. This loss the farmer believes to be the result of premeditated efforts on the part of middlemen whose success, it is thought, can come from no other source than the farmers' loss.

Consequently, the farmers' ills are laid directly to the middleman and the latter's efforts to buy what he wants at the lowest possible prices. According to this reasoning the solution logically follows that to improve the farmer's condition requires either the abolition of the middlemen or else the change from private middlemen to some sort of cooperative scheme. It rarely occurs to the cheese producer that the weakness in the present marketing system is due primarily to: (1) service which is inexcusably poor; (2) higher cost in marketing than is necessary.

Marketing Needlessly Poor

The work which must be done by the marketing system in taking milk from the farm and placing it as cheese with the final consumer may be briefly classified into eight distinct kinds of service:

1. Assembling.
2. Grading and standardizing.
3. Packaging.
4. Processing.
5. Transporting
6. Storing.
7. Financing.
8. Distributing.

These services in some manner or other have to be rendered if products are to reach consumers and hence if farmers are to

succeed in disposing of their commodities. This is true no matter whether the work is done by cooperative or by private middlemen. The real questions of whether marketing should be continued under private companies or whether cooperative companies should be established to do a part or all of it hinges upon which of the two will render the best service at the lowest cost.

While there are weaknesses and hence wastes in rendering each of these eight services, by far the greatest weakness (or, stated in another way, the largest possibility for improvement), has to do with storing and distributing farm products. In these two services the private system of marketing is least helpful to the farmer. The fault is inherent in the system. Private effort subdivides volume of business to such an extreme that small volume of business per company rules. Small volume of business means high expense as proved by numerous investigations of marketing enterprises. To avoid large overhead expense small concerns do not install the equipment necessary to proper handling and storing of the product. Neither do these dwarfed enterprises attract the type of expert efficient management that is necessary to do the marketing work well.

FIG. 3.—A LOCAL CHEESE FACTORY

Farmers while appreciating the service of a local factory do not as yet realize the necessity of large volume of business per factory if it is to be operated at minimum cost. The ideal is to have the average factory turn out more cheese of a better sort that will bring more money. Attracting the best cheese makers and joining the cooperative cheese marketing system will bring improvement.

Causes of Price Fluctuation

Because of poor storing and distributing services the private marketing companies are unable to prevent needless price fluctuation. On the contrary wherever local cooperative associations have established a successful market-wide sales agency these services of storing and distributing have been so handled as to "feed" the market. That is, the farmers' products have been fed to the market instead of being seasonally dumped on it in such vast quantities that the market could not absorb them without a declining or sacrifice price. As a consequence of extending the period of marketing from a few months or from certain months of oversupply and others of undersupply to a longer period whereby sales by farmers through their marketing companies occurred about in proportion to purchases by consumers, prices have been relatively stabilized.

A comparison of conditions preceding the establishment of successful cooperative sales systems with conditions afterward reveals that they have rendered better service in storing and distributing them than did their private predecessors. For Wisconsin's cheese industry as well as for her butter industry it is safe to say that poorer service is given in storing and distribut-

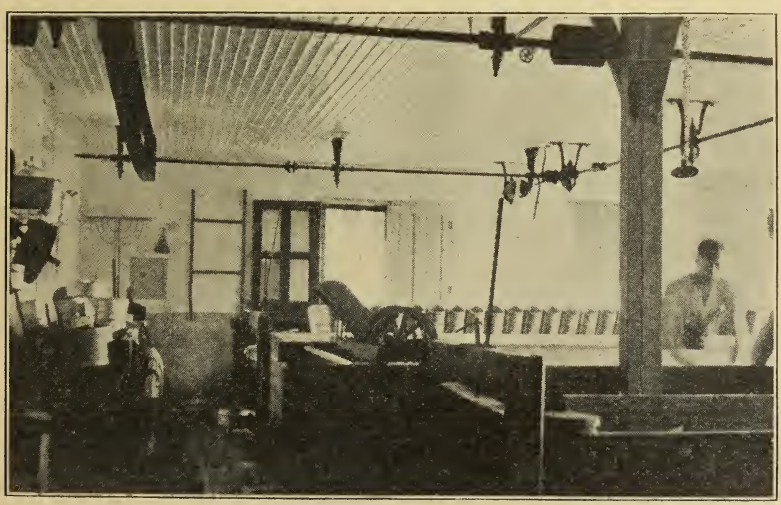

FIG. 4.—CHEESE MAKING ROOM

The cheese maker is an expert who converts milk into cheese. He is not a salesman. Hire him to make cheese but not to sell it.

ing than is possible to supply through a successful cooperative sales system.

Cooperative Marketing Reduces Operating Margin

It was found by an investigation in 1912 that when cheese was selling on the cheese boards at 11 or 12 cents a pound the cheese dealer's margin was from .75 cents to 1.5 per pound.[1] This was a margin of from 6.25 cents to 12.5 cents on each dollar of sales. It was in protest to this wide margin received by cheese dealers that the Wisconsin Cheese Producers Federation was started by farmers on the cooperative basis to reduce the cost of doing business and to improve the marketing services.

In the most expensive year of operation the Wisconsin Cheese Producers Federation (see table V) took a total margin of only 3.43 cents per dollar of sales. This was only half the former minimum margin of the private cheese dealers. It represents for the cooperative dealer a margin of only .6 cents per pound for cheese that sold at 18 cents per pound, whereas in 1912 the private dealer secured a margin varying from .75 cents to 1.5 cents per pound for cheese that sold at 11 to 12 cents a pound.

Thus a cooperative marketing company has already cut in half the relative margin secured by dealers in handling cheese. That a concern handling only 6 or 7 per cent of the state's output of cheese should be expected to do more than this, namely to stabilize prices by market feeding when it has so little of the total cheese to store and distribute is expecting the impossible. Before it can improve on these services as successfully as it has reduced the marketing margin it must be increased in size to handle the bulk of the cheese of the state.

What the Cheese Federation Is

The Wisconsin Cheese Producers Federation is a cooperative national sales company.[2] It is owned by farmers and operated by expert management engaged by the board of directors, in behalf of the 4,368 or more farmers who are patrons of the 168 local cheese factories holding membership in 1921. As with all sales companies it faces in two directions. On the one hand it comprises a line of organization from the farmer to the warehouse where cheese is assembled and paraffined. On

[1]Wis. Agr. Exp. Sta. Bul. 231, *The Marketing of Wisconsin Cheese*, p. 30.
[2]For its article of cooperative association and by-laws see pages 29-32.

TABLE I.—GROWTH OF WISCONSIN CHEESE FEDERATION SHOWN BY CHEESE HANDLED YEARLY

Year	Number of factories	Pounds of cheese received from factories	Pounds of cheese received from factories each year for every 100 pounds received in 1914
1914	45	6,125,480	100.0
1915	43	7,558,796	123.4
1916	45	7,490,020	122.3
1917	56	8,981,308	146.6
1918	63	8,522,509	139.1
1919	120	14,098,021	230.1
1920	125	13,982,817	228.3
1921	140	15,564,414	254.9
1922	145	*8,480,690	------
Total	----	90,804,050	------

* Corresponding figure for first six months of 1921 is 7,237,511. Increase of 1922 over 1921 for same period was 17 per cent.

the other hand it maintains a sales organization which distributes cheese from its six district warehouses to buyers in most of the states. In 1919 it sold and delivered cheese in 37 states. Figures 1 to 10 and tables I to VIII give an idea of the organization and how it handles cheese.

Growth of the Federation

In spite of obstacles, the Cheese Federation has made substantial growth. During 1921 it handled 15,564,414 pounds, or more than 6 per cent of the American cheese produced in Wisconsin. Far more important than volume of business, it has shown that Wisconsin farmers can unite their local associa-

TABLE II.—INCREASE IN VALUE OF FEDERATION'S BUSINESS SHOWN BY TOTAL ANNUAL PAYMENTS TO FACTORIES

Year	Dollars paid to factories for cheese	Dollars paid to factories each year for each dollar paid in 1914	Net price per pound for cheese paid to factories	Per cent price increase over year 1914
	Dollars	Dollars	Cents	Per cent
1914	855,328.64	$ 1.00	14.302	----
1915	1,115,795.20	1.30	15.085	5.4
1916	1,300,520.24	1.53	17.567	22.8
1917	2,144,005.05	2.51	24.087	68.4
1918	2,258,163.73	2.64	27.052	89.1
1919	4,243,938.56	4.96	30.108	115.4
1920	3,640,608.49	4.25	25.71	80.0
1921	2,851,546.13	3.34	18.02	26.0
1922	*1,421,749.21	----	17.42	21.8
Total	$19,831,655.25	----		

* First six months.

tions. It has proved that such federations can hire experts who will efficiently sell products in consuming markets. Furthermore, it has made Wisconsin farmers think in terms of comprehensive marketing systems. While this undertaking has not done all that farmers want to accomplish, yet it has gone as far as its volume of business permits. To do more necessitates the support of more farmers. It needs ten times the present membership and volume of business to render the best service.

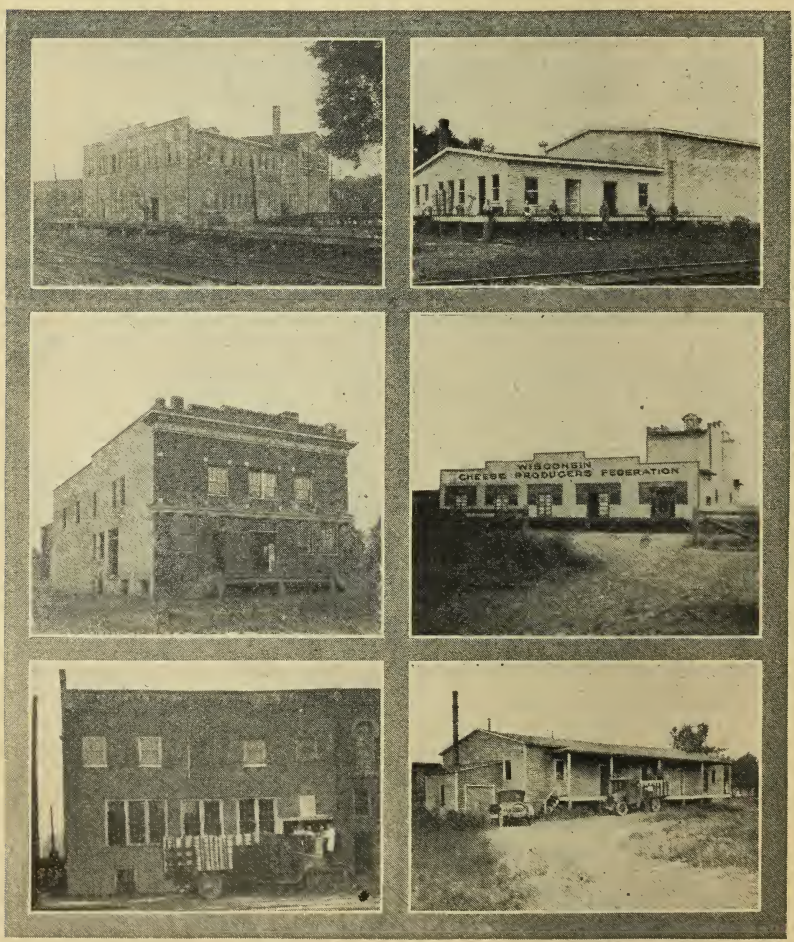

FIG. 5.—COOPERATIVE CHEESE MARKETING WAREHOUSES

Each of the above six warehouses forms the center of a district exchange. As shown in Fig. 2 six of these district groups unite to maintain the national cheese sales company. These plants are located respectively as follows: A—Plymouth, B—Spring Green, C—Pine Island, Minnesota, D—Wausau, E—Green Bay, F—New Richmond.

Storage of Cheese Surplus

As yet the federation has not tried to hold over the seasonal surplus of cheese. First, it markets too small a fraction of the cheese of the state to be able to feed the market and thereby stabilize prices. There is but one answer to the farmers' question, "Why doesn't the Federation prevent low prices?" Before it can do this, the Federation must be large enough to keep the surplus cheese of the flush season off the speculator's market and hold it for the effective consumers' market during the rest of the year. That is, if farmers hope to do away with the drop in cheese prices that usually occurs annually they must have a federation so large that it can prevent the temporary glutting of any market by holding the surplus cheese for a better time of selling. A large part, or even all, of this surplus is being stored at present by private agencies. The farmers contend that there is manipulation to get this cheese at low prices. As a matter of fact, if prices were not relatively low these speculators would not buy cheese to be held over for winter sale. It is the great surplus during the flush producing season, out of all proportion to current use, which gives the speculator his chance. The only remedy worth considering by farmers is for them to retain ownership of the surplus until consumers need it. This in turn can be done only through a large, powerful federation which really feeds the market. At present the very lack of this organization makes it unavoidable for farmers to glut and starve the cheese markets periodically. For the same reason, the markets for other farm products are periodically either oversupplied or undersupplied.

Although the Cheese Federation, during its almost nine years of operation, has not solved all the problems of cheese marketing, it has built a firm foundation for future growth. Similar early stages of growth must be passed through by any new sales company designed to market other products. A brief survey of its progress toward successively lower operating costs will surprise those who have been too hasty in criticism. It will emphasize that the growth of successful cooperative marketing companies is gradual and that too much should not be expected of cooperation in a day.

Steady Growth of Federation's Business

When the Federation started business on April 1, 1914, cheese began coming in from 45 local cheese factories in and about Sheboygan County. During the first nine months of operation 6,125,480 pounds of cheese were received. The cheese producers marketed $855,328 worth of their product. During the following two years the Federation held its own in spite of

FIG. 6.—PARAFFINING CHEESE

Cheese must be paraffined or otherwise packaged before it is fit to ship. This is done at central points where grading, branding, holding in cold storage, and loading into cars are also done at minimum cost per pound.

many difficulties; and in 1917 a period of substantial growth began. By 1921, as Table I indicates, the quantity of cheese handled had more than doubled, while the value of the business had more than trebled. The number of factories sending cheese had increased from 45 to 140. As the Federation expanded and therefore had to handle not only more cheese but was receiving it from many more counties, warehouses at Spring Green, Pine Island, Minnesota, Wausau, Green Bay, and New Richmond became necessary. The map (Fig. 2), shows the

location of each of the 140 factories sending cheese to the Federation during 1921 and includes the twenty-eight new factories joining up to September, 1922. The local cheese factories vary from 50,000 to 300,000 pounds of cheese annually. The average factory sold more than 111,000 pounds of cheese through the Cheese Federation during 1921.

Distribution of Sales

When most of the business of the Federation came from farmers in Sheboygan county, all of the cheese was assembled at the Plymouth warehouse. The expansion which has taken place in eight years of growth has added to the system five new warehouses in as many different districts. In the future, as the expansion spreads to other parts of the state more warehouses will be operated to facilitate efficient paraffining and shipping of cheese. In fact the interest in the Federation in other sections of the state is constantly crystalizing in the form of starting new district groups several of which are on the point of opening warehouses. Cheese is shipped from these warehouses to various parts of the United States on orders given by the sales manager. During 1919 over 14 million pounds of cheese were sold in 37 states. Table IV shows that more than 100,000 pounds were shipped to each of 22 states.

Operating Costs Are Small

Wisconsin farmers, planning to establish other federated sales companies will find their greatest encouragement in the efficiency of this one. Being owned by farmers, the Federation pays all its receipts, less expenses, to the account of the local cheese factories. The deduction for expenses has amounted to the very small item of 1.2 cents to 3.43 cents out of every dollar received for cheese marketed. Table VI shows that actual expenses have increased since 1917. This has been due entirely to the high cost of supplies, to increased wages, to enormously increased freight rates and to necessary activities for expanding the size of the organization. In spite of increased costs, board prices or better on an average have been paid to the account of local cheese factories.

Form of Organization

The organization is made up of three essential parts. First are the local cooperative cheese factories or associations. Second

are the district exchanges with their cold storage warehouses and equipment for paraffining cheese. Third is the sales organization now so well known as the Wisconsin Cheese Producers Federation. Each of these parts of this cooperative system have specialized duties to perform in making the whole enterprise a success.

Service of the Local Unit

The importance of the local cheese factory where an expert converts milk into cheese is too well known to need emphasis. Here it is that the usual cheesemaker receives the milk from an average of 26 patrons for each of the 168 or more factories belonging to the Wisconsin Cheese Producers Federation. During 1919 factories belonging to the Federation produced an average output of a little less than 120,000 pounds of cheese. For 1921 a larger number of factories averaged about 111,000 pounds of cheese.

TABLE III.—SOURCES AND VOLUME OF CHEESE HANDLED BY FEDERATION WAREHOUSES, 1921.

State	County	Warehouse at	Pounds of cheese received	Number of local cheese factories
Wisconsin	Sheboygan, Outagamie, Calumet, Brown, Manitowoc, Washington, Winnebago, Waupaca, Fond du Lac, Kewaunee, Marinette, Oconto, Ozaukee	Plymouth	12,323,70[illegible]	84
	Sauk, Iowa, Dane, Vernon, Crawford	Spring Green	2,539,059	26
	Lincoln, Marathon, Shawano	Wausau	(1)	25
Minnesota	Dodge, Goodhue	Pine Island	701,660(2)	26
Total			15,564,423	161

(1) No cheese received at Wausau in 1921 as the warehouse was not opened for business until February 1, 1922.

(2) Represents the volume of business for September to December, 1921, covering the period since joining the central sales organization.

No careful investigation has recently been undertaken in Wisconsin to show what is the complete cost of cheese making. In selected instances, however, the cost varied from as low as 3.4 cents to 4.1 cents per pound.[3] The Wisconsin Department of Markets in a published estimate of the cost of making cheese presents items totaling 3.93 cents per pound. On the other hand the most comprehensive investigation yet made of local cheese factory operating costs, the recent study made in the Province of Ontario, Canada,[4] shows total expenses varying from 1.58 cents per pound in the largest factories to 4.03 cents in the smallest factories. Perhaps Wisconsin cheese factories are less efficient than those of Ontario, but this is to be doubted. It is more likely that few, if any, persons know the total costs of making cheese in Wisconsin's cheese factories.

If the cost of cheese factory operation be assumed as approximately 4 cents per pound (See publicity of Wisconsin Dairy Protective Association) during a period when cheese prices averaged 18 cents a pound then this part of the work of marketing handled by local factories costs 22.2 cents out of each dollar's worth of cheese sold at wholesale. If, on the other hand, Wisconsin cheese factories are as efficient as those of Ontario where three-fourths of the cheese is made at a cost of less than 2.5 cents a pound, it is worth while knowing that efficient local cheese factory operation permits farmers to secure this valuable service at less than 14 cents out of the dollar's worth of cheese sold at wholesale instead of for a cost of 22 cents. The most efficient local cheese factories in Ontario, and doubtless the same would be true of Wisconsin's best factories, made one quarter of Ontario's total cheese output at a cost of less than two cents per pound, or only 11 cents out of each dollar's worth of cheese sold at wholesale. Thus it costs twice as much to make cheese in an inefficient instead of an efficient local factory. From a practical standpoint Wisconsin farmers in many sections can reduce the cost of cheese making by consolidating small duplicating factories and by employing the best cheesemakers only to operate these larger local enterprises. A saving of 10 per cent of the price which they now receive is a handsome addition to the income which farmers of many

[3] Report of Frostville Cheese Factory, Spring. Wis., *Sheboygan County News*, Feb. 9, 1921. Report of East Wrightstown Factory. *Sheboygan County News*, Feb. 9, 1921.

[4] *The Farmers Advocate*, June 15, 1922, p. 829.

regions may take advantage of by successfully developing efficient local cooperative cheese factories.

It cannot be overemphasized, that expert cheesemakers are greatly to be desired. They are so vital to the success of the cheese factory that higher salaries can profitably be paid for the good cheesemaker than are now given, while the reverse is also true that some cheesemakers are overpaid considering the amount of cheese they can make and the low quality of the finished product. Farmers should appreciate, as they have not done sufficiently in the past, that the best cheesemakers can be attracted only by the best pay just as the best farm hand is secured not by bidding the lowest pay but by giving the highest.

In actual practice the best paid men are costing the least per pound of cheese or per dollar of sales because they make more and better cheese than the poorer makers and because their superior product brings a premium or higher price.

Cheesemaker Not a Salesman

No matter how expert a cheesemaker may be it is certain that to make good cheese in a proper sized factory takes all his time and energy. He is employed because of his ability as a cheesemaker. He is not employed to be a cheese salesman. To expect of a properly trained and experienced cheesemaker ability and experience also in selling cheese is simply expecting more than one man can do.

Cheesemaking and real salesmanship are very different things. It is vastly more difficult to sell cheese well than to make good cheese. Wherever cheesemakers are compelled to sell cheese it should not be forgotten that most of the effort goes into the making side and the least time and effort is put on selling. It could not be otherwise so long as farmers permit cheese to be sold for each little factory separately. The cheese from a single factory is by no means a merchantable quantity. It is less than enough to justify the employment of a real salesman. This is why the selling job is loaded upon the cheesemaker on top of his cheesemaking duties. Conditions will never be satisfactory while important main line work is done as a side line by someone who already has another main line job.

TABLE IV.—PRIMARY SHIPMENTS BY WISCONSIN CHEESE PRODUCERS' FEDERATION TO VARIOUS STATES—1919 (1)

States to which 100,000 pounds or more of cheese were shipped	Pounds of cheese	Per cent
Illinois	3,178,912	22.64
New York	1,381,285	9.84
Pennsylvania	1,287,235	9.17
Indiana	783,591	5.58
Maryland	626,862	4.46
Virginia	557,124	3.97
Wisconsin	536,830	3.82
Michigan	510,679	3.64
Missouri	487,381	3.47
Iowa	468,189	3.33
Massachusetts	455,855	3.25
West Virginia	452,050	3.22
Tennessee	395,435	2.82
Louisiana	363,781	2.59
Georgia	321,725	2.29
South Carolina	198,736	1.42
California	176,388	1.26
Florida	165,975	1.18
Texas	163,423	1.16
Alabama	130,750	.93
North Carolina	124,594	.89
Ohio	108,691	.77
To above 22 states	12,875,491	91.70
To other 15 states, District of Columbia and miscellaneous	1,160,800	8.30
Grand total	14,036,291	100.00

(1) Tabulation of 1921 shipments has not been made, but this 1919 tabulation gives an approximately correct idea of 1921 primary shipments.

Because the selling side of the cheese industry is just as important as the making side it is not surprising that cheese marketing is so unsatisfactory when we consider that farmers have been having cheese made in their behalf by trained makers, but have overlooked the equally important matter of having it marketed in their behalf by trained and experienced salesmen. Cheese, so far as the farmer is concerned, has not been marketed at all. It has been dumped by the cheesemaker because he was blind on the problem of selling. If cheese were made as poorly by the cheesemaker as it is sold by him there would be no cheese industry at all. Consumers would not use the article.

Here then is the problem of the local cheese factory association. The farmers in the local association bring together a makable quantity of milk. By this is meant that they deliver at the factory enough milk to keep a man fully occupied in making it into cheese. But when it comes to marketing, the output of one cheese factory of the usual size is altogether too small to be a marketable quantity. Yet farmers have left to the cheesemaker, who is not a salesman, the task of marketing

an unmarketable quantity. A more impossible task could not be imagined.

Boards Cannot Solve Cheese Marketing

The results of having cheese sold in this inefficient manner are serious. Yet just as farmers joined to patronize or operate local cheese factories so as to have better cheese made at lower cost so also local cheese factories may join or federate to have better selling of cheese made possible at lower cost. The penalty of selling cheese by each local factory individually is the annually recurring seasonal fluctuation in prices. Few if any local factories have storage rooms for holding more than a week's make of cheese. As a result cheese is disposed of at least once a week. Many factories operate only eight or nine

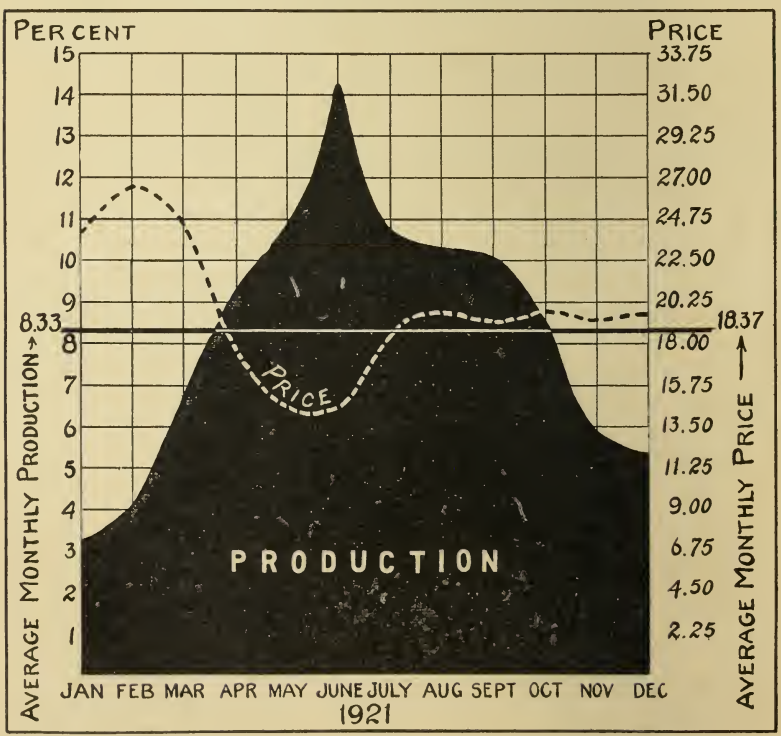

FIG. 7.—FLUCTUATION IN CHEESE PRODUCTION AND PRICES

Local factories flood the wholesale cheese market part of the time and starve it the rest of the year. Under these conditions prices inevitably fluctuate and no kind of cheese boards could stabilize them. The solution is for farmers to organize so that they may sell cheese systematically at the right instead of the wrong time. See text, pages 7-9, 13, 20-25.

months of the year, omitting the winter months. Others which receive milk the year round make from two to three times as much cheese in the months of May and June as in November and December. This means that the factories place more than four times as much cheese on the market in June as they do in January. Yet consumers eat about as much cheese in one month as another. If there is any appreciable variation doubtless more is eaten in winter. Hence local factories dispose of most of the cheese when there is the least consumer demand.

In failing to understand the principles and practice of efficient salesmanship or merchandizing farmers are not able to understand why cheese boards cannot solve the cheese marketing problem. All that these boards can do at best is to register the supply of cheese and the demand for it and to record the resulting price. As long as local factories dump great oversupplies of cheese on the boards during part of the year the price is bound to go down no matter how perfect the board may be in its organization and operation. The problem which the board cannot tackle and is not designed to solve is the fact that too much cheese is offered for sale at certain times and too little at other times.

TABLE V.—PER CENT DISTRIBUTION OF MONEY RECEIVED BY THE FEDERATION FOR CHEESE—1914 TO 1921

Year	Payments direct to member factories	Cost of freight to Federation	Actual expenses of Federation	Savings or profits
	Cents	Cents	Cents	Cents
1914	97.6	.4	1.6	.4
1915	97.5	.3	1.5	.7
1916	97.5	.3	1.4	.8
1917	97.7	.2	1.2	.9
1918	97.0	.3	1.4	1.3
1919	97.7	.4	1.4	.5
1920	97.4	.41	1.94	.25
1921	95.8	.77	3.43	.0
1922(6 mo.)	95.65	.79	3.183	.377

Note: In each year shown the number of cents or fractional cents indicated was paid out of every dollar taken in by the Federation for cheese sold.

District Organization and Warehouse Essential

To make this dumping of cheese unnecessary during the flush season requires that the surplus cheese be held over by farmers for sale at a later time instead of selling at once in a flooded market for ruinously low prices. Adequate and suitable cold storages to hold this cheese are possible in connection with the

warehouses in which cheese is received for paraffining and loading into cars. It is at each of many central points to which groups of 25 to 150 local factories each can conveniently and cheaply deliver their fresh cheese that warehouses and cold storages are needed. No local factory alone can afford to have these marketing facilities. Yet these facilities are fundamental. They are being operated by private dealers wherever the co-operative system is not operating. Without them cheese cannot be efficiently marketed. To provide these facilities requires that a number of local factories band together cooperatively, that is federate, to raise capital, install the warehouse and provide management and labor to receive cheese and operate this district marketing organization.

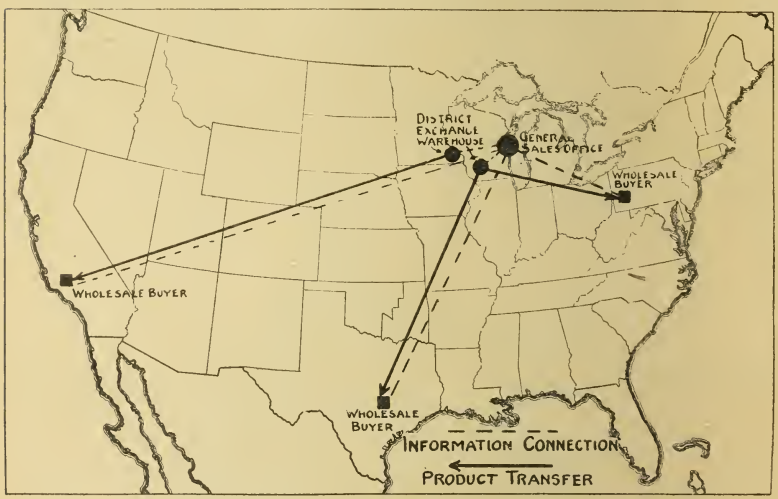

FIG. 8.—COOPERATIVE CHEESE SALES PLAN

Cheese to be marketed inexpensively must be shipped in carloads. Wholesalers who can handle carloads are located all over the United States. They cannot deal with small cheese factories as their supply is too uncertain in kind, quantity and quality. But they can deal with the representatives of a large number of factories. Hence they send orders to the General Sales Office of the cooperative system from which orders go to the nearest district warehouse to ship the cheese direct over the shortest route.

During the past eight years the cost of freight paid on cheese sent by local factories to district warehouses has varied from .3 cent to .79 cent per dollar of cheese sold at wholesale. The cost of operating the district warehouses during the same period has varied from .7 cent to 1.9 cent per dollar of cheese sold. Roughly speaking it costs less than one-tenth as much per pound

of cheese to operate a district warehouse as to operate the local cheese factory. Yet the service rendered by the district warehouse is just as necessary to satisfactory marketing of cheese as the local factory is in making it.

TABLE VI.—TREND OF WAREHOUSE EXPENSES 1914 TO 1921

Year	Wages	Supplies and other expenses	Total warehouse expense
	Cents	Cents	Cents
1914	.40	.50	.90
1915	.40	.50	.90
1916	.40	.40	.80
1917	.30	.40	.70
1918	.30	.60	.90
1919	.36	.60	.96
1920	.46	.70	1.16
1921	.87	1.03	1.90
1922(six months)	.98	.891	1.871

Note: In each year shown the fraction of a cent indicated was paid out of every dollar taken in by the Federation for cheese sold.

A fact not to be forgotten at this point is that while 26 farmers may provide a makable quantity of milk at a local factory, and while 25 to 150 local factories may provide a suitable quantity of cheese to operate an economical district warehouse, no district warehouse organization alone has enough cheese to represent a merchandizable quantity. That is to say, a single warehouse district has too small a volume of cheese by itself to permit the establishment and operation of an expert and efficient selling system.

District Organization Too Small to Advertise

For example, the large cooperative sales companies that have successfully developed national advertising campaigns have spent from .25 of 1 per cent to 3 per cent of sales in support of their campaigns. In terms of 18 cent cheese this is from .05 to .5 of a cent per pound. The average advertising program cost about 1 per cent of sales or for 18 cent cheese about .2 cent per pound. The Wisconsin Cheese Producers Federation with the 15.5 million pounds of cheese marketed in 1921 would have had an advertising expense of 1.125 cents a pound had it attempted national advertising, because such a campaign was estimated at $175,000 for the first year. To be able to conduct a campaign of this kind at a reasonable expense of .5 cent per pound down to .2 cent per pound would require from 35,000,000 to 87,000

000 pounds. In other words the Cheese Federation would need to handle from two to six times its present volume of cheese. The cheese handled in 1921 came from four district exchanges. From six to twenty district exchanges, depending upon their size, may be necessary to provide adequate cheese for successful inexpensive advertising.

Service of the Sales Organization

Just as any one district organization alone has too little cheese to advertise nationally so also it has too little to meet the expense of developing an expert sales organization with all that the word implies. The purpose and place of the central sales

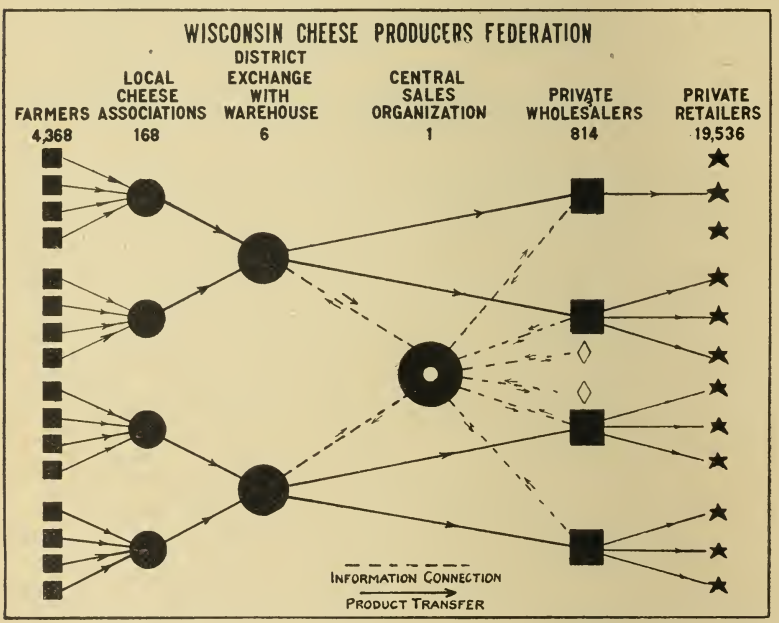

FIG. 9.—ORGANIZATION OF THE WISCONSIN CHEESE PRODUCERS FEDERATION

This cooperative marketing system is built upon the commodity principle, namely that cheese is the finished product which retailers must have on their shelves to meet consumer demands.

Farmers numbering 4,368 cluster around a local cheese factory in groups averaging 26 per factory. They deliver milk to 168 factories which then deliver cheese to 6 district warehouses. From these warehouses cheese is then ready to go to wholesale buyers after they are found. The central sales organization is maintained by the 6 district groups to do the work of getting orders for all the cheese that the 168 factories turn out. Note that the cheese moves direct as far as possible to buyers instead of going in round-about ways looking for them The central sales office makes this possible.

organization is to bring together a large enough number of district organizations to provide the volume of cheese needed to justify its existence.

Improvement in the services of marketing, particularly storing and market feeding coupled with active salesmanship and ad-

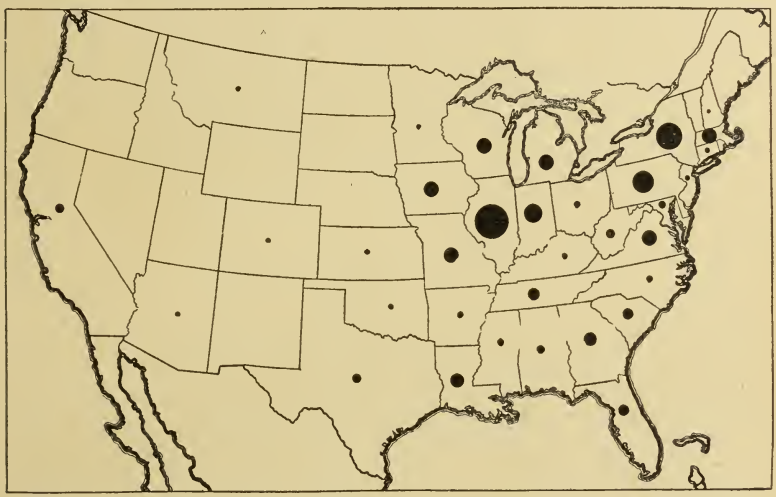

FIG. 10.—FEDERATION MARKETED CHEESE THROUGHOUT THE UNITED STATES

Each of 22 states received more than 100,000 pounds of cheese from Wisconsin factories through their selling organization—the Federation. About 3,200,000 pounds went to Illinois; 780,000 pounds to Indiana; and 108,000 pounds to Ohio. See Table IV.

vertising cannot be brought about without a central sales company. Moreover such a company with its possibilities for improving marketing conditions cannot be established without immense volume of business. For small industries as the cranberry or walnut industry most of the output of the industry is needed

TABLE VII.—TREND OF FEDERATION MANAGEMENT COSTS— 1914 TO 1921

Year	Salaries	Other office and general expenses	Total management expenses
	Cents	Cents	Cents
1914	.50	.20	.70
1915	.40	.20	.60
1916	.30	.30	.60
1917	.30	.20	.50
1918	.30	.20	.50
1919	.27	.17	.44
1920	.47	.30	.77
1921	.80	.76	1.56
1922(six months)	.68	.632	1.312

Note: In each year shown the fraction of a cent indicated was paid out of every dollar taken in by the Federation for cheese sold.

for success. In other lines a smaller proportion may permit successful operation. The main point is that there must be sufficient volume to bear the expenses of the sales organization without making the cost per pound of cheese burdensome.

In the past the costs of operating the Cheese Federation's Sales System has ranged from .44 of a cent to 1.56 cents per dollar's worth of cheese sold at wholesale. The main task in keeping sales costs low is to have an abundance of cheese to sell. The problem of securing volume is to gain numerous loyal district organizations as members, and for each of these district organizations to secure the largest possible number of local cheese factories as their members. Obviously the larger these individual cheese factories are, by virtue of a large farmer membership all producing milk for cheese making, the more volume of cheese each warehouse will receive.

How the Federation Has Benefited Farmers

Everyone who considers the Cheese Federation of course wonders what it has accomplished for its members, for farmers in general, and for the state at large. For its members it has marketed (up to July 1, 1922) 90,804,050 pounds of cheese, paying them on an average Plymouth Cheese Board Prices. In addition it has paid to its members in patronage dividends more than $75,000, and has on hand a property, the Plymouth warehouse, worth not less than $75,000. These combined patronage dividends and savings in property amount to .125 of a cent per pound on all of the cheese sold by the Federation since it opened its doors for business.

Patronage Profits and Savings to Members

More important than the services rendered to the 4,200 farmer members whose cheese had been marketed, is the effect which its operation has had upon competitive conditions. The Cheese Federation, by its existence and competition with private dealers throughout Wisconsin, has narrowed the cheese dealers' margin from the former figure of .75 of a cent to 1.5 cents taken when cheese sold at 11 cents to 12 cents a pound down to .6 of a cent taken on 18 cent cheese. It has by its competition reduced a margin averaging at least 8 cents on each dollar of sales to less than 4 cents on the dollar of sales.

Reduced Margin Benefits Cheese Industry

This saving of 4 cents on each dollar's worth of cheese sold at wholesale means $2,000,000 a year to the industry. It goes to the cheese producers of the state because there is a farmers cheese marketing company influencing the competitive system by cooperative principles. While the members of the organization have gotten slightly more for their cheese up to this time, a worthwhile thing in itself, the great financial benefit of the Federation has been diffused throughout the industry. All cheese producers have benefited as a result of the patience, faith and loyalty of some 4,000 members to their cooperative enterprise.

Cooperative Idea Benefits State

More important even than the reduced cost of doing business and what this saves the farmers of the state, is the proof which the Wisconsin Cheese Producers Federation has made that Wisconsin farmers can succeed if they will be loyal to sane and wisely formulated cooperative plans and ideals. This organization seeks success by rendering necessary services better than they were previously rendered and by reducing the costs of doing business. It claims no monopoly powers, nor does it want them. Even if attainable, monopoly efforts would only result in legal difficulties and costs and in ultimate suppression. That a group of farmers has been able to build a sales company operating throughout the state of Wisconsin during a period of less than nine years and during all this time has been able to meet the competitive test and continue to grow is a demonstration that is educationally helpful not alone to cheese producers but to the producers of other important Wisconsin farm products. It is an object lesson invaluable for those seeking understanding through the extension and other educational systems in the state.

Largest Benefits of Federation Still Ahead

By far the most important results of cooperative cheese marketing still lie ahead of the organization. In 1921 (See Fig. 7) cheese prices fluctuated from above 24 cents to below 14 cents a pound. The average price was about 18 cents. During two months of flush production 25 per cent of the year's cheese was

dumped on the markets by the local factories. An orderly movement of cheese during these two months would have been 17 per cent of the year's output. The excess movement of cheese in this period, amounting to 8 per cent of the year's output, was responsible for a depression of 4 cents per pound below the average price for the year and below the average price in April and in July. Cheese dumped by factories during May and June at a sacrifice of 4 cents a pound sold later above 19 cents. To so store and feed cheese to the market that this practice of dumping could no longer seasonally oversupply markets at one time and starve them later should at least result in a saving of 1 cent a pound. It might accomplish more than this.

TABLE VIII.—VARIATION IN MONTHLY RECEIPTS OF CHEESE BY THE FEDERATION, 1921

Month	Pounds of cheese received at Plymouth warehouse	Pounds of cheese received at Spring Green warehouse	Total pounds of cheese(1)	Per cent
January	454,019.50	47,938.25	501,957.75	3.38
February	561,088.00	49,251.25	610,339.25	4.11
March	909,687.00	80,337.25	990,024.25	6.66
April	1,216,531.75	177,710.00	1,394,241.75	9.38
May	1,326,337.25	298,296.75	1,624,634.00	10.93
June	1,709,891.75	406,422.75	2,116,314.50	14.24
July	1,289,397.00	329,466.75	1,618,863.75	10.90
August	1,204,136.00	328,345.25	1,532,481.25	10.31
September	1,207,530.50	301,910.50	1,509,441.00	10.15
October	1,036,066.75	260,394.00	1,296,460.75	8.72
November	711,733.00	156,980.50	868,753.50	5.84
December	697,242.00	102,006.00	799,248.00	5.38
Year	12,323,703.50	2,539,059.25	14,862,759.75	100.00

(1) Excludes 701,660 pounds of cheese received at Pine Island, Minnesota, warehouse because it was in operation as a part of the central organization only the latter four months of the year. Incorporation of these figures would obliterate the seasonal tendency of cheese production.

A further saving of 1 cent per pound is equal to 5 cents on the dollar's worth of cheese at 20 cents a pound. It amounts to more than the dealer's profit three or four times over. It also amounts to more than it has been possible to reduce the cost of doing business. That it is an amply worthwhile object no one can deny. It is a goal ahead of the Cheese Federation which can be reached in all practical reason, provided that Wisconsin cheese producers supply it with the volume of business which would make these objects attainable.

Volume Essential to Big Results

To feed the market requires that the seasonal surplus be kept by farmers until the time when its release upon the market will not cause flooding. This is a simple proposition. The difficult task is to have a large enough part of the cheese producers act together to see that the surplus does not reach the market until the right time. Farmers cannot hope to act successfully on the marketing of a product as individuals. It is out of the question—impractical. To render these services—namely storing and distributing—which will place the seasonal surplus on the market when it will sell to advantage requires large volume of business in the hands of a single sales organization. It is to provide this necessary size of business as a basis for rendering better marketing service and hence of giving farmers larger returns from cheese that the Wisconsin Cheese Producers Federation merits the state-wide support of all thinking cheese producers.

The following copy of the revised articles of Cooperative Association, drawn up for adoption by the Cheese Federation constituency, will give interested persons the latest information about the organization of cooperative sales companies in Wisconsin:

For further information consult or write to any of the following: Wisconsin Cheese Producers' Federation, Plymouth, Wisconsin; Department of Agricultural Economics, College of Agriculture, Madison, Wisconsin; Wisconsin Department of Markets, State Capitol, Madison.

ARTICLES OF COOPERATIVE ASSOCIATION

Know All Men By These Presents, That the undersigned have associated and do hereby associate themselves together for the purpose of forming a Cooperative Association under sections 1786e—1 to 1786e—17, inclusive, of the Wisconsin statutes, and do hereby make, sign, and agree to the following:

ARTICLES OF INCORPORATION

Article I

The name of this Association shall be Wisconsin Cheese Producers' Federation, and its principal place of business shall be in the city of Plymouth, County of Sheboygan, State of Wisconsin, P. O. address, Plymouth, Wisconsin.

Article II

The business and purpose of this association shall be to buy and sell, or act as agent to buy or sell, cheese and by-products; to manufacture cheese and by-products; to buy and sell, or act as agent to buy or sell, cheese factory and creamery equipment and supplies; to manufacture cheese factory and creamery equipment and supplies; to own and operate warehouses and cold storages; to own and hold stock in any corporation or cooperative association within

the limits prescribed by law; to buy, lease, own, sell, exchange, and deal in all forms of property necessary or incident to the transaction of the business of this association; and to do all other things necessary or incident to the transaction of the business of this association.

Article III

The capital stock of this association shall be .....
.....dollars, which shall be divided into .....
shares of the par value of.....
.....dollars each.

Article IV

The shares of capital stock of the association are non-assessable.

Article V

The affairs of the association shall be managed by a board of seven directors. The directors shall be elected by the stockholders of the association at such time and for such term of office as the by-laws may prescribe.

Article VI

The names and residences of the persons forming this association are:

BY-LAWS OF THE WISCONSIN CHEESE PRODUCERS' FEDERATION

Article I

The regular annual meeting of the stockholders shall be held on the second Thursday of February of each year. The president of the board of directors may call special meetings of the stockholders upon ten days' previous notice thereof to each stockholder by publication or by personal service.

The president of this association shall call a district meeting at each warehouse point not more than thirty days prior to any annual or special meeting of this association. At each district meeting the stockholders shipping to such warehouse point may elect one delegate for each ten stockholders or for any lesser number and one delegate for the remaining fraction of the whole number of stockholders. Each delegate at the stockholders' meeting (or his appointee in his absence) shall be entitled to cast one vote for every stockholder represented by him; provided, that no delegate shall represent more than ten stockholders.

Voting by proxy in this association shall not be permitted except as provided herein.

Article II

The directors shall be elected annually at the regular annual meeting of the stockholders and shall hold their offices for one year or until their successors are elected and qualified. Every warehouse point shall be represented by at least one director. No person shall be a director unless he is or has been a milk producer and a member of a cooperative cheese producers' association.

The regular meeting of the board of directors shall be held within ten days after the regular annual meeting of the stockholders. The secretary of the board shall call special meetings thereof upon order of the president or of any three directors, but notice of any special meeting shall be given to all directors not joining in the call therefor. Every meeting of the board of directors shall be open to the Director of the Division of Markets and notice of every such meeting shall be given by the board of directors to said Director of the Division of Markets.

The directors shall elect from their number a president, vice-president, secretary and a treasurer, and shall employ such salesmen, inspectors and other employes as may be necessary and shall fix the compensation of all officers and employes.

The directors shall require any officer or employe to whom funds of the association are entrusted to furnish bond.

A majority of the board of directors shall constitute a quorum for

the transaction of business, but a less number may adjourn from day to day giving notice to absent members of said board of such adjournment. Any vacancy occurring in the board of directors shall be filled by the remaining members thereof.

Article III

The officers of this association shall be a president, vice-president, secretary and treasurer. The duties of secretary and of treasurer may be performed by one and the same person, who, in such case, shall be known as secretary-treasurer.

The principal duties of the president shall be to preside at all meetings of the stockholders and of the board of directors and with said board to have general supervision of the affairs of the association. He shall sign all certificates of stock and all contracts and other instruments; provided that the board of directors may authorize any officer or agent of the association to perform this duty unless prohibited by law.

The principal duties of the vice-president shall be to discharge the duties of the president in the event of the absence or disability of the latter.

The principal duties of the secretary shall be to keep a true and correct record of the proceedings of the board of directors, and to safely and systematically keep all books, papers, records, and documents belonging to the association or pertaining to the business thereof. He shall countersign and affix the seal of the corporation to such papers and documents as shall be required to be countersigned or sealed; provided that the board of directors may authorize any officer or agent of the association to perform this duty, unless prohibited by law.

The principal duties of the treasurer shall be to safely keep and account for all moneys and other property of the association which shall come into his hands, and to keep an accurate account of all moneys received and disbursed by him and to retain proper vouchers for all moneys disbursed and to render such accounts, statements and inventories as may be required by the board of directors.

The officers of the association shall perform such additional duties as may from time to time be imposed by the board of directors or as may from time to time be prescribed by the by-laws.

Article IV

The term of office of all officers of this association shall be one year (unless the office be declared vacant before the expiration of the year) or until a successor has been elected or appointed.

The board of directors shall have authority to remove any officer for cause or any employe at any time, and shall fill any vacancy caused by any such removal.

Article V

The directors shall apportion the earnings by first paying dividends on the paid-up capital at a rate not to exceed six per cent, annually, and then setting aside ten per cent of the net profits for a reserve fund until an amount has accumulated in the reserve fund equal to one hundred per cent of the paid-up capital stock. The remainder of the net profits shall be distributed as required by law.

Article VI

The board of directors shall have authority to issue shares of stock or the promissory notes of this association, in payment of patronage dividends to stockholders and to provide for a method of rotating capital based upon the tonnage of cheese marketed by the stockholders through this association.

Article VII

(Note—Article VII was excluded by the vote of the annual meeting in 1920.)

Every stockholder of this association shall enter into a contract to sell to this association all of the cheese produced by or for such

stockholder, or such part thereof as this association may require, which contract shall be of two years' duration, continuing thereafter from year to year subject to the right of the stockholders to terminate liability under such contract at the end of any year after giving notice to the board of directors of this association at least thirty days before the expiration of such year and affording to the board of directors of this association a hearing before the stockholder in this matter. The requirements of the contract herein shall not affect the right of a stockholder to dispose of cheese to its members for their individual use.

Any stockholder violating the agreement to sell its cheese, as provided herein, shall pay to this association—as liquidated damages—a sum equal to one cent per pound for each pound of cheese produced but not delivered by it according to the provisions contained herein; and said sum may be deducted from any money due from this association to the stockholder.

Article VIII

Each cooperative association or corporation, which owns stock in this association, shall conform to all lawful rules and regulations adopted by this association for the manufacture and preparation for shipment of cheese and by-products.

Article IX

Stock in this association shall be transferred by the owner or its agent only on the books of this association.

Article X

No stockholder shall sell or otherwise alienate its stock in this association except after depositing it with the secretary thereof, who shall have the authority, if exercised within thirty days, to sell or otherwise dispose of the stock as the board of directors may approve, paying to the owner of the stock the par value thereof, after deducting any amount due from the stockholder to this association. In the event that the secretary does not exercise the option to sell the shareholder's stock within thirty days after the shareholder has deposited said stock with the secretary, the secretary shall return the stock to the shareholder who may then sell or otherwise alienate it in any manner not prohibited by law.

Article XI

The board of directors shall have authority, upon giving ten days' notice in writing, to call in the stock of any stockholder upon payment of its par value, after deduction of any amount due from the stockholder to the association; provided, that not more than ten per cent of the paid-up capital stock shall be thus called in during the period intervening between any two annual stockholders' meetings, unless authorized by a vote of the stockholders in the same manner as is prescribed for amendment of these by-laws.

Article XII

These by-laws may be amended by a vote of the majority of the stockholders at any regular or special meeting; provided that notice proposing to amend the by-laws at a special meeting shall be given in the call thereof.

W5b Ag. Sci.

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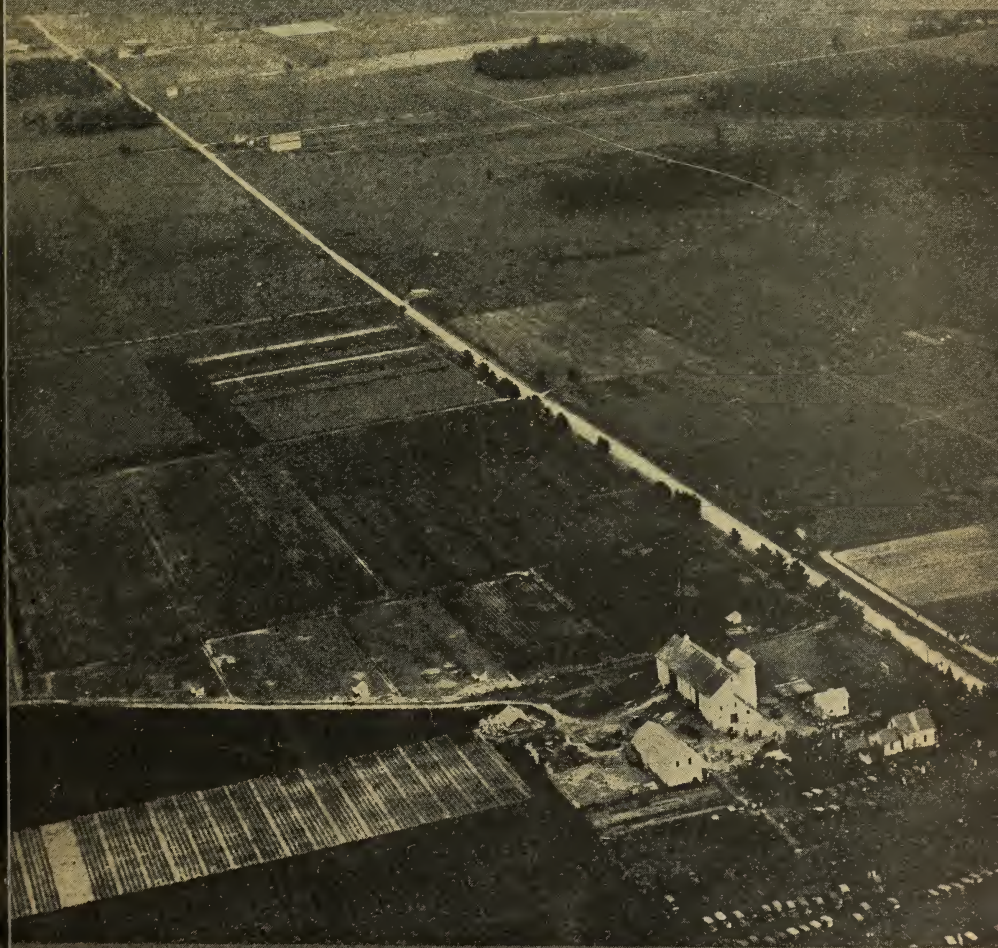
Farming the Silt Loams of Central Wisconsin



AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Surface drainage is important and is one of the first things to consider in farming heavy silt loam. Plowing in narrow lands with dead furrows connected with good outlets is recommended. Page 7

Plowing to a depth of 6 inches in the fall has been found most desirable, with the possible exception of corn, where spring plowing has given best yields. Neither subsoiling, deep tilling nor deep plowing have been found profitable for the crops grown in the rotation. Page 12

Lodging of oats causes serious losses, due primarily to unbalanced soil conditions. Early maturing varieties and others adapted to this soil type should be grown. Applying manure on second-year hay instead of the corn crop, and planting corn after corn have been found helpful practices to reduce losses from lodging. Page 20

The heavy silt loam is acid, and requires about 2 tons of limestone per acre. Limestone furnishes plant food as well as overcoming acidity of the soil. Page 22

Clover is the best general legume crop to grow. Soybeans are also excellent forage crops and yield good tonnage. Page 23

Dairy products and livestock are the principal sources of income of farmers in the heavy silt loam region. Where only a limited amount of millstuffs is fed, the use of phosphate fertilizers supplementing stable manure is advised. Page 27

In applying fertilizers, all the crops grown in the rotation should be considered. Broadcasting is, therefore, recommended. Applying small amounts of fertilizer in the row or hill is justified in the case of corn in order to hasten growth, but the bulk of the fertilizer should be applied broadcast. Page 33

The cover photograph is an aeroplane view of part of the Marshfield Experiment Station Farm. Some of the experimental plots are shown in the foreground.

Farming the Heavy Silt Loams of Central Wisconsin

F. L. Musbach

HEAVY SILT LOAM is the most important soil type in central Wisconsin. It occupies an area between 5,000 and 6,000 square miles in the heart of the state—an area equal to Connecticut and Rhode Island combined.*

The soil is adapted to a wide range of crops and when properly managed excellent yields are obtained. The soil is close textured and retains moisture to a marked extent, so that surface drainage is of first importance. The silt loams have a high degree of native fertility and when the plant food supply is maintained, big yields may be expected. The growing of legume crops, use of ground limestone, and supplementing the manure with phosphate fertilizers makes a combination that means permanent fertility as well as profitable crop yields.

How Climate Affects Crops

The influence of climate on crop production is generally recognized. Rainfall and temperature are especially important. The relation of the soil itself to rainfall and temperature is another important factor. Heavy silt loams, for example, hold moisture especially well and where drainage is not ample the soil remains cold and is considered backward. The importance of having a soil in good fertile condition, therefore, cannot be too strongly emphasized. This applies particularly to the corn crop, which requires a warm soil and responds especially well either to stable manure or commercial fertilizer.

The rainfall, as a rule, is ample in central Wisconsin, and the distribution is also ideal. Spring is sometimes late, but usually the temperature conditions are excellent for crop germination. At the Marshfield Station, temperature and rainfall records were maintained since 1913. (See Table I.)

*The management of this type of soil brings up problems of special interest to farmers now in the area as well as to the new settler. The Marshfield Experiment Station was established in 1912 and the results of the nine years' work are briefly given in this bulletin.

FIG. 1.—AREA OF HEAVY SILT LOAM SOIL IN CENTRAL WISCONSIN

This soil comprises a section equal to approximately one-tenth of the entire state.

TABLE I.—RAINFALL RECORD IN INCHES AT MARSHFIELD STATION. 1913-1921

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1913	.88	.86	3.30	2.48	6.22	2.70	3.50	3.88	3.13	2.31	1.33	.24	30.83
1914	1.56	.69	1.12	3.09	2.23	10.17	2.27	3.56	5.04	2.32	.83	.92	33.80
1915	1.69	1.61	.70	.51	5.36	3.84	6.38	3.20	2.40	2.91	4.86	1.09	34.55
1916	2.18	1.19	1.85	2.47	4.61	6.31	2.52	3.53	5.44	3.04	2.00	.87	36.01
1917	2.97	.55	1.10	2.24	2.14	4.21	6.05	8.41	1.33	3.00	.15	.48	32.63
1918	1.05	.75	.75	2.85	7.97	3.02	2.81	2.19	1.17	2.40	2.16	1.64	28.76
1919	.41	1.09	2.20	4.11	3.02	4.71	5.96	4.70	2.11	3.64	3.59	.81	36.35
1920	1.76	.40	2.23	2.13	3.65	4.92	1.02	1 52	1.74	3.55	2.63	2.45	28.00
1921	.15	.60	1.60	4.52	3.11	3.30	3.32	1.21	3.12	1.16	1.40	2.43	25.92
Nine year average	1.40	.86	1.65	2.71	4.25	4.79	3.76	3.58	2.83	2.70	2.11	1.21	31.86

On the average for nine years the heaviest rainfall came during the growing season—May, June and July. During this period, 12.70 inches, or practically 40 per cent of the total rainfall, comes. The average annual rainfall for nine years is 31.86 inches.

The length of the growing season averages 128 days, based upon the records for nine years at the Marshfield Experiment Station, as shown by Table II.

TABLE II.—DATES OF LAST FROST IN SPRING AND FIRST IN AUTUMN

Year	Last in spring	First in autumn
1913	June 10	Sept. 22
1914	May 15	Sept. 9
1915	May 17	Aug. 27
1916	May 2	Sept. 15
1917	May 24	Sept. 10
1918	May 1	Sept. 10
1919	April 29	Oct. 11
1920	May 14	Sept. 30
1921	May 16	Oct. 4

In Table II 30° F. was taken as the temperature determining date of frost. Only twice during the nine years has the temperature reached 30° F. after May 20. As a rule, little or no injury is incurred in late spring frosts.

Autumn frosts are more liable to cause injury, especially to corn. For several years soft corn was harvested during the period of 1913 to 1921. In part this was due to early fall frosts and in part to unfavorable growing weather during June and July. The crop grown on well-drained, fertile soil matures earlier and is, of course, less liable to suffer from these unfavorable conditions.

Soil Made Up of Silt and Clay

The surface soil is essentially a uniform greyish colored silt loam, containing a large proportion of fine earth particles called silt, hence the name, silt loam. In texture it is somewhat between a loam and a clay loam.

The subsoil varies somewhat in texture and color. In the northern part of the district, the subsoil to a depth of 18 to 30 inches is a light gravelly and sandy material. In the southern portion, the area is underlain by a heavier subsoil, frequently spoken of as "hard pan," chiefly because this layer does not permit the rapid downward movement of water.

FIG. 2.—EXPERIMENTAL PLOTS AT MARSHFIELD STATION

Several hundred similar plots are devoted to experimentation in variety tests, use of fertilizer, methods of tillage, and drainage.

When the soil is sifted into its various separates based upon size, it is found that silt and clay make up a large part of the total soil particles. (See Table III.)

TABLE III.—MECHANICAL ANALYSES OF TYPICAL SILT LOAM SOIL

Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
0″– 8″	.2	3.5	2.6	4.0	5.7	70.3	13 6
8″–20″	.3	3 5	3.7	5.8	7.0	64.3	15.4
20″–36″	.4	7.2	8.5	14.8	11.5	34.9	22.9

DRAINAGE OF SILT LOAM

The surface is generally slightly rolling with many nearly level areas which suffer from lack of drainage during some seasons. The greater part is rolling enough to afford good surface drainage for most crops. Tile drainage, however, on a considerable area will be found profitable to insure best yields.

The peculiar composition of the soil in size of particles makes quick passage of water through it somewhat difficult. The high proportion of silt is largely responsible for this. The soil for this

reason does not check nor crack upon drying out, so that water courses are not readily established. Surface drainage is, therefore, of importance. The internal drainage of soil is less easily remedied.

Surface Drains Important

Providing ample surface drains is the first question to which the farmer should give his attention. This simple process should be considered at plowing time. As a rule, land should be plowed in the direction of the slope and not at right angles to it. The field should be plowed in narrow "lands" with dead furrows about 20 paces apart. This distance is especially important on land that has only gentle slopes, but on the more rolling areas, dead furrows may be farther apart. It is more logical to keep water out of soil than to remove it after it soaks in.

These dead furrows should be provided with good outlets at the lower end of the field. Oftentimes these outlets may be brought together and in turn emptied into a large surface ditch. The ditch should be shallow, 12 inches at the deepest part, and 16 feet wide, with graded slopes, that permit driving over with tools and machinery. A ditch of this kind may be easily built, using a road grader and plow. It is important to keep this run-way seeded and permanent unless it is necessary to move the location.

The use of a reversible or side hill plow is, therefore, not recommended unless dead furrows are afterwards plowed out. While considerable losses occur in poor yields in the dead furrows, they are very much less than the losses which occur when the entire field suffers from lack of drainage. Then, too, the well drained land may be worked earlier in the spring. Much time is required for the water to escape by evaporation and by seepage, thus delaying planting. Besides, the poorly drained soil remains colder and this retards the germination of the grain.

In order to study the differences in temperature of soil, thermometers were placed at a depth of 1½ inches directly over tile lines and also at the same depth 2 rods distant from the tile. Frequently the soil over the tile was found to be as much as 5° F. warmer than that 2 rods from the tile line.

Tile Drainage Beneficial on Silt Loam

The first essential, that of surface drainage, has already been discussed. The soil, however, has a peculiar property of holding water tenaciously, so that while surface water is removed, yet the ground remains wet. Ten years ago when the Marsh-

FIG. 3.—A STUDY IN DRAINAGE EFFECTS ON SOIL CHECKING

This view represents a plot not satisfactorily drained. Cracks nearly one inch in width and 10 to 12 inches deep are common.

field Branch Station was established, an experiment in the profitableness of tiling the silt loam was undertaken. The question whether the tile would heave out of line was also an interesting one on which to get observations.

The field tiled in 1912 consisted of nearly four acres (3.85 acres) and a system of drainage was installed. The laterals were 4 rods apart and 4-inch tile were used. The main is 5-inch and at the lower end of the system larger sizes are necessarily required. The laterals vary in depth from a little less than 30 inches to 36 inches. The tile are laid to a grade of 2 to 3 inches for each 100 feet.

Five years ago manholes were installed into which the tile discharge. These were put in in order to study the discharge during the season and other important matters.

During the ten years no trouble has been experienced with the tile heaving out of line or otherwise breaking. The system is apparently becoming more efficient, as indicated by a study of the discharge during the past five years.

The heaviest discharge of the tile comes during the spring months—March, April and May, when the tile system on the four-acre tract discharges at the rate of 2,000 barrels of water in 24 hours. This is the maximum and occurred in March, 1920. A surprising amount of water is removed during the

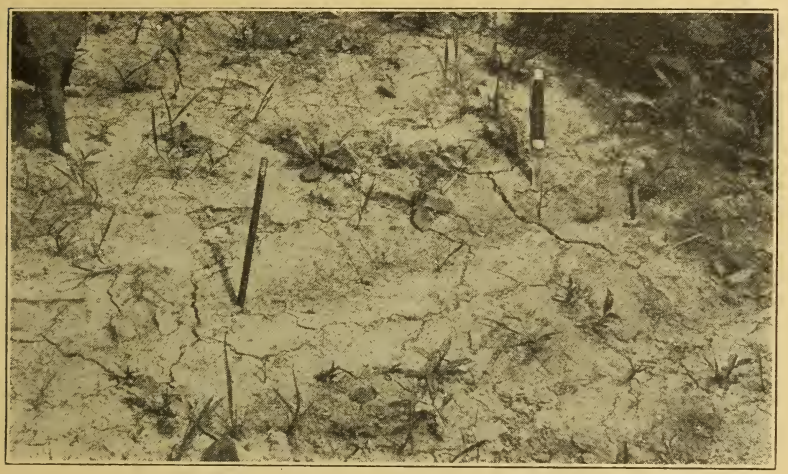


FIG. 4.—THIS PLOT HAS GOOD UNDERDRAINAGE

Note difference in checking. Compare with Fig. 3.

early part of the season, before crops and evaporation make heavy draughts on the water supply. Table IV gives the amount of rainfall and the approximate discharge from the system.

TABLE IV.—RAINFALL AND DISCHARGE FROM TILE DURING SPRING OF 1920

	Rainfall		Tile discharge		Per cent discharged in tile
	Inches	Gallons	Inches	Gallons	
March	2.23	232,528	2.280	237,832	102.2
April	2.13	222,100	.494	51,912	23.3
May	3.65	382,554	.016	16,518	4.3
June	4.92	513,020	.029	3,091	.6

The discharge is heaviest early in the season and gradually decreases as the season advances. The March discharge in the tile indicates a greater amount than came in the total rainfall. This is due in part to melting snow that fell during the

previous month, and also to some water coming from higher lying land that is picked up by the tile as seepage water. Again the readings of tile discharge were taken twice daily in the manholes, by taking duplicate readings of the time required to fill a

FIG. 5.—EFFECTS OF TILING

Tiled field in the foreground—the location of the tile lines 4 rods apart can be seen by the light colored bands of soil extending across the field.

container of known volume. This is, of course, a rather crude method and subject to error.

The effect of tile on the land is also quite marked in the spring. As a rule, the soil may be worked earlier and dries out sooner after heavy rains than it otherwise would.

Six years ago another field was tiled in a way to permit yields being obtained from small plots at different distances from the tile line. The rotation consists of barley, alfalfa (3 years), potatoes and corn. (See Table V.)

TABLE V.—AVERAGE RESULTS OF TILING
(Acre Yields for Varying Periods)

Distance of plot from tile	Corn 3-yr. av.	Barley 4-yr. av.	Potatoes 6-yr. av.	Alfalfa	
				1st yr. 4-yr. av.	2nd. yr. 3-yr. av.
Rods	Bushels	Bushels	Bushels	Pounds	Pounds
4	51.22	28.26	154.11	3,243	3,087
3	57.21	29.02	162.79	3,387	3,046
2	57.22	29.89	172.44	3,587	3,297
1	58.66	30.15	192.88	3,818	3,327

Since the manurial treatment and liming were the same on all plots, the increased yields were due to better drainage.

Substantial increases were obtained notably on the plots near the tile compared to those four rods distant, especially

FIG. 6.—CORN ADJACENT TO TILE LINES BETWEEN THE TWO PLOTS

Note the full stand and thrifty growth. Tile are laid 2½ to 3 feet deep. Compare with Fig. 7.

with potatoes and corn. Alfalfa has not made big yields, yet tiling has been helpful in increasing yields. June grass was troublesome, especially after the second year, and this was one reason for the reduced tonnage.

The cost of tiling (1915) averaged about $35.00 per acre where tile are placed 30 to 36 inches deep and laterals 4 rods apart. The increased yields paid a handsome return on the investment.

TILLAGE METHODS ARE IMPORTANT

How deep should heavy silt loam be plowed? Is spring plowing advisable? What about subsoiling, especially in sections where subsoil is tight? These are a few of the questions about tillage methods that the farmer wants answered.

The depth of plowing is important. Many prefer plowing to a depth of 8 to 9 inches in the fall of the year, others say subsoiling or deep tilling is more profitable. In order to an-

swer these questions, a four-acre field was set aside at the Marshfield Experiment Station and various tillage methods studied. The rotation included corn, oats, clover and timothy, and timothy. (See Table VI.)

TABLE VI.—RESULTS OBTAINED WITH VARIOUS TILLAGE METHODS
(Average Acre Yields for Varying Periods)

Method	Corn 6-yr. av.	Oats 9-yr. av.	Clover and timothy		Timothy 5-yr. av.
			1st cut	2d cut	
	Bushels	Bushels	Pounds	Pounds	Pounds
Fall plowed 6"	58.67	52.30	4,411	1,825	4,097
Fall plowed 3"	56.33	51.22	4,193	1,770	4,096
Fall plowed 8"	59.02	50.71	4,491	1,816	4,305
Fall subsoiled 16"	58.11	51.90	4,349	1,632	4,252
Fall deep tilled 16"	56.15	48.81	4,143	1,854	4,360
Spring plowed 6"	60.68	53.29	4,290	1,528	4,182

FIG. 7.—CORN ON TWO PLOTS FOUR RODS FROM TILE LINE
The missing hills and poor growth should be compared with tiled plots.

The important features standing out in the results are that shallow plowing (3 inches) gives poor yields for each crop grown, and that subsoiling and deep tillage treatments are unprofitable. Some increases in the case of timothy hay are to be noted due to the deep tillage treatments. Both subsoiling and deep tilling treatments, however, more than double

the cost of plowing. In fact, a tractor should be employed if either a subsoil plow or deep tiller is used extensively.

Deep plowing (8 inches) increased yields over 6-inch fall plowing in all cases except oats. The increases, however, are not marked and would barely cover the cost of extra horse power needed to turn over the additional two inches of soil.

Spring Plowing Best for Corn

Spring plowing produced the best yield on the corn crop. The sod land for corn is usually plowed ten days or so before planting. Oats likewise yields best on spring plowing for a nine-year average. The first clover and timothy cutting following oats, however, yields lowest on spring plowing. Spring plowing, however, on account of the busy season, is not recommended for any crop except possibly corn. This is the practice of many farmers who invariably report good results. Sod land is a good place on which to put manure in early fall and winter or in the spring. The young grass can then make quick growth by utilizing the plant food before both the manure and green material are plowed under, which makes ideal conditions for the corn crop. On old timothy sod, however, fall plowing helps to prevent trouble with cut worms and grubs.

With root crops it is probable that deeper plowing or stirring up the subsoil may prove profitable, although deep tillage results with grain, corn and hay show no benefit. It is the aim to try out rutabagas and other root crops in the near future, but there is sufficient evidence to show that for ordinary farm crops plowing to an average depth of about 6 inches in the fall of the year is sound practice. The corn crop is the possible exception.

Preparing Seed Bed

The silt loam soil works up easily and, as a rule, there is no trouble in preparing a good seed bed in the spring. In fact, there is danger of working the soil too much. Frequently, if a deep seed bed is disked up and heavy rains follow, soil packing results, which is difficult to overcome. This is especially serious on small grain where the ground cannot be pulverized after seeding. Cultivation may be resorted to with corn, but even then it is difficult to restore the good tilth necessary for best results.

Lodging of oats must be considered on the average farm. While there are no direct experimental results, considerable observation shows that on fairly fertile land, lodging may be more serious on soil that has been thoroughly and deeply pulverized. The deep cultivation permits air to enter and furnishes ideal bacterial conditions for releasing plant food, especially nitrates. An excessive amount of nitrates produces a rank growth of straw that lodges easily.

Careless work is, of course, not recommended, yet where lodging is a serious question, shallow preparation either by means of a disc harrow with the gangs set straight, or even a spike tooth harrow, is advisable.

CROP ROTATION BENEFICIAL

In Roman agriculture 2,000 years ago the beneficial effects of crop rotation were well understood. One writer puts it, "The land must rest every second year, or be sown with light kinds of seeds, which prove less exhausting to the soil." Again, "Some of the leguminous plants manure the soil." The reasons underlying the effects of rotation and benefits of legumes were not understood, yet the practice was followed then as well as now.

In discussing rotations, farm crops may be divided into three classes:

1. **Grain crops**—generally shallow feeders, add little humus or organic matter, and tend to weediness.

2. **Hay crops**—legumes, timothy, etc. Legumes have extensive root systems, tap roots, add organic matter or humus and also plant food (nitrogen). They also improve the physical condition of the soil.

3. **Cultivated crops**—Corn, potatoes, etc., conserve moisture, favor decomposition of organic matter, and destroy weeds. Some are deep feeders, as corn, while root crops are shallow feeders.

A good rotation should necessarily include crops belonging to each of these three classes. The value of such practice is apparent in its effect on the physical condition of the soil, on weediness, on organic matter supply, on plant diseases, and on nitrogen supply of the soil. Better yields are, therefore, obtained when crops are rotated than when a single cropping system is followed.

FIG. 8.—"STATION DAY" IS AN ANNUAL AFFAIR

A group of interested farmers inspecting the crops on the Marshfield Experiment Station Farm. Farmers and their families from Central Wisconsin counties enjoy their visits to the Farm.

Again, crop rotation permits raising livestock and means diversified farming. No one will deny the benefits of this type of farming in stabilizing farm business and making best use of labor and equipment the year around.

It should not be understood, however, that crop rotation means maintaining the supply of plant food better than where a single cropping system is practiced. In fact, quite the contrary is the case.

The Illinois Experiment Station furnishes some interesting data on crop yields. Crops were grown continuously on some plots, while on others a three-year or a five-year rotation was followed. None of the plots received manure or commercial fertilizer for forty years.

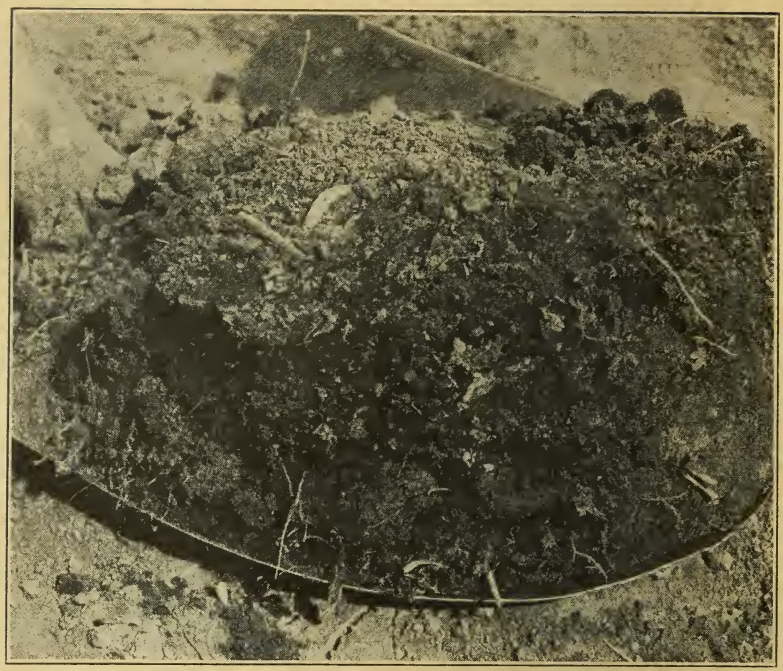


FIG. 9.—SOIL FROM PLOT WHERE ROTATION IS PRACTICED

The rotation included legumes. Note the mellow condition of soil, also the vegetable matter present. (Courtesy of Minnesota Experiment Station.)

TABLE VII.—YIELDS FOR TEN-YEAR PERIODS FROM 1888 TO 1917

	Corn every year	2-yr. rotation		3-yr. rotation		
		Corn	Oats	Corn	Oats	Clover
First ten years—(1888-1897)	40.9	42.5	41.6	52.1	45.3	2.34
Second ten years—(1898-1907)	32.9	42.4	37.5	55.7	48.4	Crop failure as rule
Third ten years—(1908-1917)	28.3	37.6	38.6	40.7	42.4	

The corn yields in the early years averaged about 70 bushels per acre on all plots. The plots are located on heavy silt loam soil of the corn belt prairie of Illinois.

The yields of corn where grown every year show a steady decline, and this is likewise true of the two-year rotation. In the three-year rotation, the last ten-year period showed a marked drop in yield over the preceding period. In a large

measure this is due to clover failures which occurred during the last two ten-year periods, when only two clover crops were obtained.

Soybeans were used as a substitute crop, but are much less efficient than clover in supplying organic matter and nitrogen to the soil in roots and stubble. The heavier crops likewise remove larger quantities of plant food—phosphorus, nitrogen, potassium, etc. In other words, rotating crops makes it possible to get larger yields and this involves the removal of larger amounts of plant food.

The clover crops have built up the supply of nitrogen and organic matter. Chemical analysis would indicate higher content of both in the three-year rotation plot than in either of the other two. In fact, the increased yields are in a large measure due to the organic matter and nitrogen contributed by the hay crops that have made possible the increases. Of

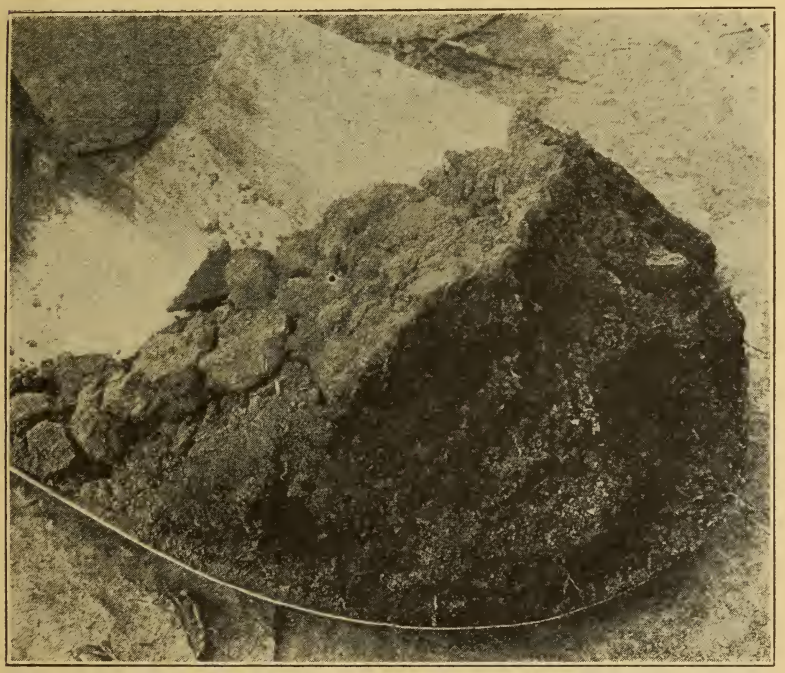


FIG. 10.—WHERE CORN IS GROWN CONTINUOUSLY THE SOIL TENDS TO BAKE

Note absence of organic matter and cloddy conditions. (Courtesy of Minnesota Experiment Station.)

course, this should not be taken as an argument against rotation. But no farmer should think that because rotation of crops makes productive yields possible temporarily, it, therefore, maintains the supply of plant food elements in the soil. (The exception is, of course, nitrogen if legumes are maintained in the rotation.)

It is often said that certain crops are "hard" on the soil in the sense that they remove more plant food than other crops. In part that is true, but a more important difference is that some plants remove more of certain elements than others. Again, a crop like corn, because of its root development and length of growing season, may utilize plant food that is less soluble. (See Table VIII.)

TABLE VIII.—PLANT FOOD REQUIRED BY AVERAGE FARM CROPS

Crops	Phosphorus	Potassium	Nitrogen	Calcium	Total
Corn ---------- 60 bu.	10.2	13.3	60.	.47	
Corn stover ---------- 3 T.	6.0	52.0	29.	30.4	
Total ----------	16.2	65.3	89.	30.87	201.4
Oats ---------- 50 bu.	7.0	7.3	33.	1.8	
Oats straw ---------- 1¼ T.	3.0	31.2	19.	6.8	
Total ----------	10.	38.5	52.	8.6	109.1
Barley ---------- 30 bu.	5.2	6.0	19.2	.6	
Barley straw ---------- 1.5 T.	2.0	21.5	13.0	5.7	
Total ----------	7.2	27.5	32.2	6.3	73 2
Wheat ---------- 20 bu.	5.1	7.08	28.4	.67	
Wheat straw ---------- 1.5 T.	2.4	25.0	15.0	6.51	
Total ----------	7.5	32.08	43.4	7.18	90.16
Rye ---------- 30 bu.	6.6	8.1	31.5	.75	
Rye straw ---------- 2 T.	3.2	26.0	18.4	4.40	
Total ----------	9.8	34.1	49.9	5.15	98.95
Red clover ---------- 2 T.	7.3	73.6	80.0	49.4	210.3
Alfalfa ---------- 4 T.	19.0	66.5	200.0	90.4	375.9
Soybean hay ---------- 2 T.	9.5	71.0	93.0	55.0	228.5
Timothy ---------- 2 T.	4.5	22.5	34.0	7.0	68.0
Millet ---------- 2 T.	6.6	51.0	25.5	12.4	95.5
Potatoes ---------- 200 bu.	9.0	60.0	22.0	3.2	94.2
Rutabagas ---------- 10 T.	10.4	81.0	38.0	3.0	132.4

Potatoes require relatively more potassium; corn draws heavily on nitrogen; while legumes are heavy feeders of lime (calcium) and also require large amounts of phosphorus, potassium and nitrogen (some of which may be extracted from the air in the soil). Again, grain crops and roots require plant food that is readily available, while corn is less particular in this respect.

By properly rotating crops, therefore, the soil is subjected to these different "feeding characteristics." One crop compensates for the other, and there is maintained more nearly a balanced condition than with the single crop system.

There is no one best system of rotation for the silt loam soils. The rotation depends on the system of farming, and this depends largely on the personal choice of the farmer, for some prefer one system and some another. It is highly desirable to rotate crops, but a serious mistake to think that rotation takes the place of other equally sound practices, such as liming and fertilizing.

The silt loam area of central Wisconsin is noted as a diversified farm section. Dairying and livestock raising are the principal sources of income. The crops grown must, therefore, include succulence, silage or root crops, grain crops, and forage crops—clover and other legumes.

Succulent Crops Needed

Corn is, no doubt, the best all around silage crop. Sunflowers have been tried, and while the tonnage exceeds that of corn, yet this does not overcome many of its undesirable features. Wisconsin No. 8 and Golden Glow have produced 12 to 14 tons per acre, and with favorable seasons can always be depended upon to make excellent silage. Root crops have also found favor, especially in the newer sections where frost is more serious than on the older more developed areas. At the Conrath Demonstration Farm the average yield for five years has been 23 tons per acre of rutabagas (Hurst's Monarch). The roots are drilled-in in rows, thinned and cultivated the same as corn is drilled in rows.

Oats and rye are two dependable small grain crops. Barley yields well, though the crop is not as certain as the other two. Wheat is subject to rust and is not grown to any extent.

Lodging Is Serious Problem

During the past ten years lodging of oats has become a serious problem, especially detrimental in many cases on account of the bad effect on clover seeding. If the heavy oats nurse crop does not smother out the clover completely, it re-

FIG. 11.—LODGING IS A SERIOUS PROBLEM

Lodging is frequent on many farms on the heavy silt loam. The weather, soil conditions, and variety of oats are factors influencing lodging.

duces its vitality so that after the oat crop is removed, only favorable distribution of rainfall will enable the clover crop to make thrifty, vigorous growth before winter. At the Marshfield Station in 1920 a reasonably fertile field produced a heavy crop that lodged before harvesting. Within a month after the oats were harvested, the entire new seeding had disappeared except in two foot strips where no nurse crop was seeded.

Lodging is due to a number of causes, over some of which there is no control. The primary cause of lodging is an unbalanced soil; that is, a soil relatively high in nitrogen and humus, or organic matter. The crop grown on a soil in which nitrates (compound of nitrogen) are available in abundance, produces a weak straw lacking in stiffness and easily broken down in unfavorable weather. Early maturing varieties of oats have the advantage in that they ripen earlier and thus avoid the bad weather conditions that frequently come later in the summer.

State's Pride or Wisconsin Pedigree No. 7, an early oats of the Kherson stock, has suffered less from lodging and its at-

tendant bad effects on clover seeding than has heavier Swedish Select, Wisconsin Pedigree No. 5. In point of yield the Pedigree No 7 has also maintained its own, outyielding in some years the heavier strawed oats. Wisconsin Pedigree No. 1 is another variety that, while heavy in straw, stands up better than other late maturing varieties.

Frequently the farmer with poor native pasture is forced to pasture new seeding in the fall. This is a bad practice, as it reduces the chances of having any clover hay the following season.

Barley and rye are better nurse crops. Both come off early and are not subject to lodging. Fall rye should be grown more generally, because it is a safe crop and thus far little, if any, trouble has been experienced in getting good clover

FIG. 12.—THE MOST IMPORTANT LEGUME FOR THE HEAVY SILT LOAM

Timothy is a more common crop than clover in many sections.

stand with rye as a nurse crop. The usual practice is to seed red clover early in the spring before the frost is out of the ground. A good rate of seeding is 10 to 12 pounds per acre, with some timothy seed. The alternate freezing and thawing will furnish cover, so that on the silt loam soil no harrowing is necessary to cover the seed.

Clover or Timothy for Forage

The silt loam soil of Central Wisconsin has been called "Clover Land." The name may still be used on the newer lands opened for farming purposes. On the older cropped lands, however, clover failures are common. Clover here has been replaced to a marked extent by timothy. In some areas farmers have given up the growing of clover entirely and depend, instead, on the timothy, which is so much more easily grown and which returns good yields for three to six years or even longer if top dressing is resorted to.

The dairy farmer, however, finds timothy a poor substitute for clover in compounding his dairy ration. Not only is the protein content much less, but minerals also are woefully lacking in timothy. (See Table VIII and compare calcium content of clover, alfalfa, and soybeans with timothy.)

Silt Loams Are Acid

The silt loams, even in the virgin condition, are acid. Analyses made at this Experiment Station, however, show that the soil on old cropped land contains a good supply of calcium, though not in an available condition. Land just broken up is certain to contain more available lime on account of easily decomposing humus found invariably in new soil. No doubt this is one important reason why clover does so much better on new land. The phosphorus supply, too, on the newer soil is more readily available. Legume crops, as a whole, are exceptionally heavy feeders of lime, and also draw heavily on the phosphorus supply. (See Table VIII.)

Liming silt loam soils has been found good practice, not only to furnish readily available lime for the legumes, but also to better conditions for the development of the legume bacteria.

Alfalfa also requires an abundance of lime, and thus far it has not been found a profitable crop on silt loam soil. Alfalfa may be grown, but should be seeded on well-drained land only —preferably rolling to hilly land.

Where clover fails, several good substitutes that have been tried out successfully may be used. It should be understood, however, that these are substitutes, not in any case as good as clover.

FIG. 13.—CORN AND SOYBEANS

This is an excellent succulent combination for silage.

Soybeans are a splendid crop for the silt loams. The crop may be grown for hay, or silage with corn, or for seed. For hay, broadcasting or drilling in solid drills has been found satisfactory. A good plan is to drill a mixture of sudan grass with soys at about corn planting time. The mixture cures better than soys alone. In curing the hay, make medium sized

haycocks after the leaves are thoroughly wilted, and allow it to stand for four or five days, or longer if weather is unfavorable. The crop is then turned over to dry out and hauled in.

Oats and peas also make excellent combination hay and good yields are obtained. One and one-half bushel of each per acre is an average rate of seeding.

Rotation for Silt Loams

The following four-year rotation is used quite extensively by the average farmer:

TABLE IX.—FOUR-YEAR ROTATION FOR HEAVY SILT LOAM.

	Kind of crop	For home consumption	Cash crops	Substituted crops
First year	Cultivated	Corn—rutabagas	Potatoes, etc.	
Second year	Small grain	Oats—barley	Rye—canning peas	
Third year	Forage	Clover		Soybeans for hay
Fourth year	Forage or pasture	Clover and timothy	Hay	Sudan grass or millet

Frequently the rotation is lengthened by permitting hay to remain one or more years longer. As a general rule, that is poor practice and should not be resorted to unless necessary.

The ideal arrangement, according to the rotation outlined, would be to divide the farm into fields of about equal area. On the average farm of 80 acres, about 60 acres are under plow. This would mean 15 acres in cultivated crops, and the same acreage in grain, clover, and mixed hay. This division, however, is seldom followed. The records of a large number of farms showed that the cultivated crops seldom occupy one-fourth of the land unless cash crops, as potatoes or cabbage, are important. The hay crops, as a rule, occupy 50 per cent of the land, small grains 30 per cent and corn 20 per cent. In this arrangement, sufficient silage may be grown to supply about twenty cows, and also enough small grain to furnish feed for the stock with some surplus to sell, especially hay.

Cash crops in addition to hay should also be mentioned in the general rotation outlined. The soil is adapted to considerable range of crops. The farmer who has cash crops to market is enabled to use the returns to advantage in purchas-

ing high powered proteins needed to properly balance his dairy ration.

Oats are the principal small grain crop grown. Rye and peas, however, are excellent cash crops, and may occupy a part of the area allotted to grains. Rye may be disked in following corn and does well following a cultivated crop. During the past few years, pea canneries have been established in a number of localities, and farmers have found it profitable to grow canning peas.

In the rotation scheme, provision is also made for substitute crops when new seeding fails. Oats and peas, or soys and sudan grass, have been indicated in the table. Clover seeding is not dependable, however, with soys and sudan grass but will be fairly safe with oats and peas when used for hay.

METHODS OF FERTILIZING

Manure should be handled so as to reduce losses of plant food to the least possible amount. Ordinarily, this may be done by hauling directly from the stable to the field. This practice would fit in well with the four-year rotation indicated above by applying either on the field in second year hay, or to the sod land which is to go into corn. Very little losses occur in either method unless the land is quite hilly and subjected to considerable erosion. In either case, 10 tons per acre makes a good application. Heavier applications should be avoided. It is only in farms well stocked, and with small clearings that there is any danger of having more than ten tons per acre available once in the rotation period of four years. If the corn land receives the manure application, it necessitates spring plowing of the sod land. The good results of spring plowing have already been pointed out (except in case of old timothy seed), so this plan has found many advocates.

The chief objection to applying manure to corn ground is that the small grains which follow corn are more liable to lodge. To overcome this difficulty in a measure, the plan of manuring for the second year hay crop is suggested. The corn then receives little or no manure except the residual effects.

The average dairy farm will find a phosphate fertilizer profitable, not only to offset the losses of phosphorus in the sale

of products, but also to increase crop yields and hasten maturity.

Manuring New Seeding

The clover seeding has not been given much attention until recently. In fact, it was unnecessary until recent years. The importance of maintaining clover or other legumes cannot be too strongly emphasized. The farmers, too, begin to realize this fact. A helpful practice is that of top dressing new seeding in the late fall with manure that has accumulated in yards and old straw piles. Even though the application is only a light one of three to four loads per acre, this top dressing will do much to protect the young plants. Where straw is available, there is no better place for it than on the new seeding. Straw attachments are now made to fit standard manure spreaders.

Maintaining the Plant Food Supply

Does the average dairy farmer maintain the supply of plant food in his soil? Although he may answer "yes," yet he frequently overlooks the fact that maintaining the supply of plant food and keeping up the fertility of the soil are not necessarily the same. A fertile soil is one that has the ability to produce good crops. It is not concerned alone with the supply of plant food, nor with drainage, nor tillage, nor crop rotation, but with all of these factors.

During the past fifty years much has been learned about better tillage methods and tillage implements. The horse hoe and the seed drill were the results of Jethro Tull's efforts in England early in the 18th century. Underground drainage and crop rotations are practices that have been known and used for centuries.

These practices—crop rotation, improved tillage, drainage, and better seeds—in themselves are sound; yet every one serves to remove larger amounts of plant food, nitrogen, phosphorus, potassium, and lime.

Nitrogen—This element may be brought into the soil and the supply maintained and even increased through the growing of legume crops. In a general way, about one-fourth of the land under cultivation on the farm should be in one or more legumes—clover, alfalfa, soybeans, or others. The millstuffs fed by the dairy farmer furnish another source of nitro-

gen. Protein feeds—oilmeal, cotton seed meal, and others are especially high in their nitrogen content. In general, therefore, the dairyman may depend on the legume crops and the millstuffs to maintain and even increase the nitrogen supply of his soil.

Potassium—Approximately three-fourths of the potassium in grain crops and corn is found in the straw or stover, and in a large measure is returned to the soil. The total supply in the silt loam soil averages nearly 40,000 pounds over an acre to a depth of eight inches. Considering this abundant supply in the soil, and the small losses that occur, the potassium supply on average dairy farms is ample for good crop yields without buying fertilizer containing it. The important thing is to make available the abundant supply now found, by maintaining organic matter and by other good cultural practices.

Phosphorus—This element is found largely in the seed or kernel of the crops grown. About two-thirds of it is found in the grain and corn and only one-third in the straw or stover. Legume crops are also heavy feeders of phosphorus. In feeding these crops to the dairy animal there are many sources of loss. These may not be large for any one year, yet when the practice is continued for a long period the effect is shown in reduced crop yields.

The losses of phosphorus come in the sale of dairy products, such as whole milk, in the sale of cash crops, and in the handling of stable manure. Milk contains considerable amounts of phosphorus, chiefly lime prosphates. For example, the milk produced by a cow averaging 5,000 pounds per year when sold removes as much phosphorus annually as is removed in an average wheat crop of 14 bushels per acre. This assumes also that the wheat straw is returned in the manure without loss.

The loss of this valuable plant food may be offset either through the purchase of millstuffs, such as bran, for example, or by the use of phosphate fertilizers. Dairymen are using large quantities of millstuffs and in many cases are enabled to offset the losses that occur or even to build up the supply in the soil.

From a careful study of 250 dairy farms in the state, the amount of millstuffs fed was determined. In the table is given the percentage of farmers using various amounts of millstuffs. No commercial fertilizers were reported by any of the farmers whose farms were examined.

TABLE X.—PERCENTAGE OF FARMERS USING MILLSTUFFS (250 farms)

22.6%	of farmers used no millstuffs.
19.4%	of farmers used 0–2 tons
12.0%	of farmers used 2–4 tons
12.0%	of farmers used 4–6 tons
9.0%	of farmers used 6–8 tons
25.0%	of farmers used over 8 tons

The herds averaged 16 to 18 cows per farm. Nearly one-fourth of the farmers were depending upon home grown feeds entirely; about one-third were using up to 4 tons; one-fifth from 4 to 8 tons; while only one-fourth were using over 8 tons per year. It is safe to state that, except in the last two groups, comprising 34 per cent of the farms, the outgo of phosphorus exceeds the income for any one year. In general, one-half ton of wheat bran is to be fed per animal a year in order to play even so far as the phosphorus exchange is concerned. The farmers who gave these figures depend principally on dairy products and livestock for their income. Milk is delivered to cheese factories, or the cream to creameries. The loss

FIG. 14.—A CHECK PLOT ON LAND CROPPED ABOUT TWENTY YEARS

The five-year average yield on this plot was 45.4 bu. No manure was put on this land for ten years preceding.

of phosphorus is, of course, somewhat greater when milk is sold to cheese factories than in the latter case. The skim-milk or whey is, as a rule, fed to hogs or calves. If either product is fed entirely to hogs the loss of phosphorus is bound to be large on account of the way hogs are raised on the farm. The up-to-date hog raiser usually keeps hogs in pasture lots for summer feeding so that these lots receive practically all the benefit of the manure produced by the animals. So far, therefore, as the farm as a whole is concerned, little benefit is derived from the manure produced when milk, whey and millstuffs are consumed. The pasture lots, therefore, are certain to become enriched markedly.

Where the dairy by-product, milk or whey, is fed to calves and the manure returned to the fields, there is a much better distribution of the plant food over the farm. The growing animal, however, extracts more of the fertilizing elements, especially phosphorus, than do the mature animals.

Phosphorus is the plant food element about which the dairy farmer should be chiefly concerned. The losses that come in the sale of products, in leaching, in surface erosion, and in the way manure is handled, are important and every effort should be made to replace them. In a measure, the commercial fertilizers and millstuffs do offset the losses, yet the net losses during any one year for the entire state are enormous. (See Table XI.)

TABLE XI.—ESTIMATED LOSSES AND GAINS FROM FEEDING STUFFS AND FERTILIZERS

Loss of phosphorus in livestock sold in 1918	6,158,000 lbs.
Loss of phosphorus in milk sold in 1918	3,622,000 lbs.
Loss of phosphorus in crops sold in 1918	8,050,000 lbs.
Loss of phosphorus in handling manure in 1918	3,900,000 lbs.
Total	20,730,000 lbs.
Gain of phosphorus in millstuffs and fertilizers purchased in 1918	7,700,000 lbs.
Net loss for the year	12,960,000 lbs.

Depleting the soil each year will eventually impoverish it. In several of the older counties, the loss of phosphorus in the cropped soil has been found to be nearly one-third of the total found in uncropped or virgin soil. These farms have been under crop for fifty years, and in early years were devoted largely to grain raising.

FIG. 15.—THIS PLOT RECEIVED MANURE, LIMESTONE AND PHOSPHATES

This treatment on a five-year average has increased yield 15 bu. per acre, or nearly 35 per cent over check plot, Fig. 14.

EXPERIMENTS WITH MANURE SUPPLEMENTED WITH OTHER FERTILIZERS

At the Marshfield Station a four-acre field was set aside for fertilizer experiments. The soil is typical heavy silt loam and has been under crop about twenty years. The experiments were started in 1913, but previous to that time the land had been in general farm crops and probably received several applications of manure.

Phosphate Fertilizers with Manure

The rotation consisted of corn, wheat, oats and clover. On account of black rust, wheat was dropped in 1921 and barley substituted.

Manure is top dressed on corn land at the rate of 10 tons per acre. The acid phosphate is distributed with the manure by spreading the proper amount evenly over the top of the load. In this way the acid phosphate is broadcasted and the crops succeeding corn are also benefited. As a general farm practice, this method of applying fertilizer is recommended.

TABLE XII.—RESULTS OF SUPPLEMENTING MANURE WITH ACID PHOSPHATE

	Corn, 5-yr. av.	Wheat, 5-yr. av.	Oats, 6-yr. av.	Clover, 4-yr. av.	
				1st crop	2d crop
10 T. manure 2 T. limestone	56.84 bu.	15.05 bu.	57.37 bu.	2,886 lbs.	1,917 lbs.
10 T. manure 2 T. limestone 450 lbs. acid phosphate	60.41 bu.	16.21 bu.	60.49 bu.	3,090 lbs.	1,889 lbs.
Increase due to phosphate	3.57 bu.	1.16 bu.	3.12 bu.	204 lbs.	—28 lbs

While the increases from the use of phosphate fertilizer have not been large, it should be borne in mind that the land has been under crop but a short time. Again, the land has been in clover every fourth year since 1912 and no doubt the effect of the rotation has been important in liberating plant food. Then, too, the manure used on all plots comes from animals fed liberal amounts of millstuffs, and thus the phosphorus hunger is not so apparent as on older cropped land less well supplied with manure of the kind used in this experiment. The effect of maintaining clover in the rotation should not be overlooked, for without question, it has an important effect on all crops following.

The importance of the effect of the rotation is shown by yields obtained on a plot which has received no manure nor fertilizer since 1912 and perhaps only one or two applications since the land was brought under cultivation twenty years ago. The yields are:

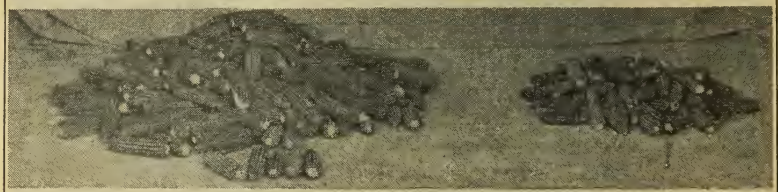
Corn	44.87	bushels
Wheat	10.05	bushels
Oats	54.78	bushels
Clover—		
First crop	2070.7	pounds
Second crop	1583.2	pounds

Applying Fertilizers

When planning his fertilizer program, the farmer should keep in mind all of the crops grown in the rotation. He should remember that phosphate fertilizers are not leached out of

UNTREATED PLOT UNDER CROP ABOUT TWENTY YEARS

It has received no manure since 1912 and perhaps one or two treatments before the plots were laid out. Yield 1921, 54.50 bu. with 32.9 per cent nubbins.



GOOD EFFECTS OF MANURE AND LIMESTONE

This combination raised the yield and also the quality. Yield 66.4 bu. and nubbins 19 per cent.

RESULTS OF USE OF MANURE AND PHOSPHATE

This plot produced 70.4 bu. of which 19.4 per cent was inferior corn.

MANURE, LIMESTONE AND PHOSPHATE

When manure is supplemented by phosphate in addition to limestone, the maximum yields are obtained—77 bu. with only 10.6 per cent nubbins.

the soil, and that crops succeeding the one receiving the treatment will likewise be benefited. This is brought out plainly in the figures above. Frequently the clover is in need of phosphate and in that case broadcasting phosphates for small grains is highly desirable.

On the heavy silt loam, however, the method of applying a light application of 150-175 pounds per acre for corn along the row or in the hill is justified. Frequently the season is late and the soil is slow in warming up. Applying fertilizers near the corn row, but not in contact with the seed, starts corn off earlier and tends to hasten maturity. Either the acid phosphate or a mixture known as 2-12 may be used. A fertilizer attachment for the corn planter is necessary.

The use, therefore, of 300 to 400 pounds of acid phosphate broadcasted with manure for corn or without manure for small grain, and a light row application for the corn crop makes a well balanced fertilizer program for the dairy farmer on the heavy silt loam. If, however, he is able to make but one application of fertilizer, preference should be given broadcasting.

Potash Fertilizers—The supply of potassium in the silt loam as found by repeated chemical analyses is about 40,000 pounds per acre eight inches. The question whether potassium could be used profitably on dairy farms was therefore studied. (See Table XIII.)

TABLE XIII.—RESULTS OF USE OF POTASSIUM ON DAIRY FARMS

	Corn, 5-yr. av.	Wheat, 5-yr. av.	Oats, 6-yr. av.	Clover, 4-yr. av.	
				1st crop	2d crop
10 T. manure 2 T. limestone 450 lbs. acid phosphate	60.41 bu.	16.21 bu.	60.49 bu.	3,090 lbs.	1,889.5 lbs.
10 T. manure 2 T. limestone 450 lbs. acid phosphate 200 lbs. potash	57.98 bu.	16.25 bu.	56.93 bu.	2,919 lbs.	1,889.7 lbs.

Potassium gave negative results with corn and oats, and on the other crops in the rotation the increases were negligible. Table XIII does not indicate the need for potash, but this re-

sult does not apply to other crops, such as potatoes, nor to other heavy potash feeders, nor to other soil types. Further study by means of trial plots will be necessary to find out the needs of these special crops in different soils.

Gypsum—Gypsum or land plaster has long been used for agricultural purposes. The practice would flourish for a time and then cease for a decade or more until it was again taken up by enthusiastic advocates. Recently the Oregon Experiment Station found that under their conditions of soil and climate, gypsum gave very profitable increases.

Gypsum has been used since 1915 and the results are shown in Table XIV.

TABLE XIV.—RESULTS OF USE OF GYPSUM ON DAIRY FARMS

	Corn, 5-yr. av.	Wheat, 5-yr. av.	Oats, 6-yr. av.	Clover	
				1st cut.	2d cut.
10 T. manure 800 lbs. rock phosphate 2 T. limestone	60.51 bu.	14.66 bu.	59.89 bu.	3,098 lbs.	1,922 lbs.
10 T. manure 800 lbs. rock phosphate 2 T. limestone 450 lbs. gypsum	59.68 bu.	14.81 bu.	58.56 bu.	3,094 lbs.	2,115 lbs.

Experimental results show that the farmer is not justified in investing in gypsum. Clover is the crop to which the material is applied at the rate of 450 pounds per acre. This is broadcasted in the spring before the crop has made much growth. The clover crop, therefore, should show increases. In the second cutting this amounts to 193 pounds, while in the first it is 4 pounds less on the plot receiving gypsum. The results do not justify the use of gypsum on the other crops grown in the rotation.

Ground Limestone—Heavy silt loam is an acid soil, but the degree of acidity varies according to the cropping treatment, drainage, and length of time the land has been under plow.

Liming the heavy silt loam is sound practice and profitable yields are obtained from using some form of lime except pos-

FIG. 16.—A LIME SOWER IS BEST

There are a number of methods of applying limestone on the heavy silt loam soils, but the best method, however, is to apply by means of a lime sower.

sibly on land that has been under plow only a short time. Limestone should be top dressed on plowed land and disked in previous to seeding. Many farmers make the mistake of plowing under limestone or top dressing on clover sod, but, as a rule, poor results are obtained.

A lime sower is most satisfactory for distributing limestone, although a manure spreader in some cases can be made to work. The machine is set on low gear and some manure or litter is first placed in the bottom of the spreader to prevent the limestone from filtering through.

Limestone may be applied at any time and with any crop, except possibly potatoes. The usual method is to apply on the field to be seeded to small grain and clover, but some prefer to use it on the corn ground. In this way the lime has an opportunity to react with the soil a year before the small grain and clover, seeded the year following. In either case, the material is disked in thoroughly before planting the crop.

Table XV gives liming results. Two tons of finely ground limestone are used once in the four years, but tests indicate

that the second application may be reduced to possibly one ton and equally good results obtained.

TABLE XV.—RESULTS OF LIMING HEAVY SILT LOAMS

	Corn, 5-yr. av.	Wheat, 5-yr. av.	Oats, 6-yr. av.	Clover, 4-yr. av.	
				1st crop	2d crop
10 T. manure 800 lbs. rock phosphate 2 T. limestone	60.51 bu.	14.66 bu.	59.89 bu.	3,098 lbs.	1,922 lbs.
10 T. manure 800 lbs. rock phosphate	52.89 bu.	14.79 bu.	55.14 bu.	2,770 lbs.	1,756 lbs.
Increase due to liming	7.62 bu.	.13 bu.	4.75 bu.	328 lbs.	166 lbs.

The increases due to liming have been consistent each year. Every crop in the rotation except wheat has shown increases due to liming. The wheat crop has practically every year been seriously injured by the black rust, so that liming as well as fertilizer treatments have not shown any marked effect.

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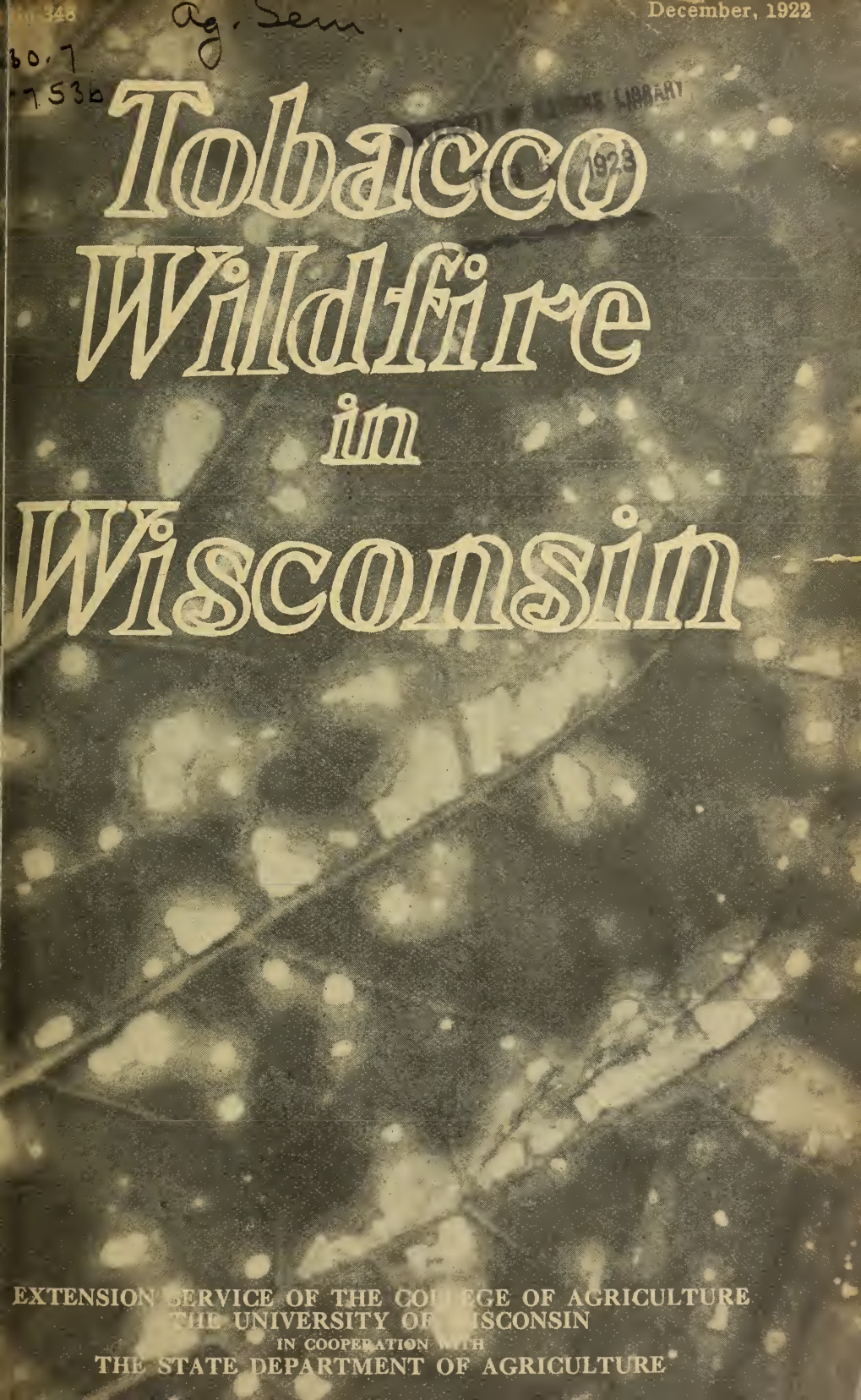
Tobacco Wildfire in Wisconsin



EXTENSION SERVICE OF THE COLLEGE OF AGRICULTURE
THE UNIVERSITY OF WISCONSIN
IN COOPERATION WITH
THE STATE DEPARTMENT OF AGRICULTURE

DIGEST

A tobacco disease new to Wisconsin occurred in this state during the season of 1922. This disease, known as wildfire, has shown itself to be sufficiently serious in other tobacco districts to warrant Wisconsin growers using all possible measures to prevent its occurrence in their fields. A control campaign is under way in the infested district. Page 3

Wildfire resembles "ordinary rust" in some respects. Careful comparison shows, however, that they are quite different in appearance, but much more important is the fact that wildfire is capable of doing a hundred-fold more damage than "ordinary rust." Page 8

Wildfire is caused by infections of the leaves produced by certain bacteria (germs). It is, therefore, infectious and can spread from leaf to leaf, plant to plant, and from farm to farm. The control of the disease depends upon preventing an excessive spread of these bacteria. Page 11

Storms spread the disease, produce more or less wounding favoring infection, and supply moisture, without which the bacteria are unable to enter the leaf. The weather, therefore, has a very important part in determining the amount of damage done by the disease. Page 18

Practically all bacteria die out over winter since they have no living plants on which to multiply. A few, however, escape destruction and in some manner reach the seed-beds in the spring. The best possibilities for control lie in preventing seed-bed infection. Page 19

Plants infected with wildfire should never be transplanted to the field if it is at all possible to obtain healthy plants elsewhere. Even apparently disease-free plants from infected beds should preferably not be used. Page 20

Plants and leaves found infected in the field should be destroyed so far as practicable. Infected material serves as a source of further spread in the field and aids in carrying the disease over into the following year. Page 20

Tobacco Wildfire in Wisconsin

James Johnson and S. B. Fracker*

WILDFIRE is a serious disease of tobacco which has just appeared in Wisconsin, although it has been known in other tobacco districts of the United States for about six years. In the aggregate it has caused losses amounting to millions of dollars. Tobacco growers must now recognize that they have a new disease to contend with and therefore use every precaution to prevent their fields from becoming infested.

Mild cases of wildfire resemble "ordinary rust" and for that reason it is important that growers learn to distinguish the disease and to apply control measures in time. Preventing seedbed infection and avoiding the use of plants from infected seedbeds are possible means of control.

The Wisconsin outbreak in 1922 did not cause any considerable damage, owing largely to unfavorable weather conditions for its spread. The disease did, however, seriously threaten to destroy a few crops early in the season, indicating its dangerous possibilities under Wisconsin conditions. The fact that wildfire may cause large losses to tobacco has been amply illustrated in southern and eastern tobacco districts. Like most plant diseases, however, wildfire is sporadic and while heavy losses may occur in some seasons there may also be seasons of comparative freedom from it as has been the experience in other states.

Wildfire in Other Tobacco Districts

Wildfire first occurred to a serious extent in North Carolina in 1917, so far as is definitely known. From there it spread rapidly to other tobacco districts of the United States until now it is found in practically all the tobacco growing sections, involving as many as fourteen states. This is an exceedingly rapid spread for a plant disease in a six-year period and suggests the ease with which it may spread from farm to farm when once it has entered a district. In these other tobacco districts the damage to infected fields has varied greatly, ranging from insignificant

*The authors represent the College of Agriculture, University of Wisconsin, and the State Department of Agriculture, State Capitol, respectively.

amounts to almost complete destruction in any one year, and from very widespread and general damage to hardly any signs of the disease in different years. The aggregate loss in the six-year period has run, however, into millions of dollars, and although other tobacco diseases are known to produce relatively larger losses to tobacco in the United States, yet the fact remains that, in years especially favorable for wildfire, far heavier losses than yet observed may occur.

Infected Area in Wisconsin

Diseased plants from seed-beds were brought to the Experiment Station on June 14, 1922, from the town of Deerfield, Dane county, and the disease was soon after determined to be wildfire. While the original infected area in the beds was a relatively small spot, the disease later spread over most of the beds from which about twelve acres were transplanted. As an eradication measure this planting was destroyed and replanted with healthy plants. No further signs of infection were seen on this farm until late in the season, when very slight spotting was noted in a small percentage of the plants.

About one week after the first case was reported, a second one was found in the town of Burke and a preliminary survey showed that several cases existed in this township. Arrangements were then made with the State Department of Agriculture to co-operate in checking or eradicating the disease.[1] A conference of tobacco growers from the town of Burke and vicinity was then called and met with officials of the State Department of Agriculture and the Experiment Station. A committee of growers to act with the officials was appointed and a campaign of control or eradication agreed upon. A detailed survey was undertaken to locate infested seed beds and fields. Wildfire was found on about ninety farms, situated largely in the northeastern part of Dane county. (Fig. 1.)

The largest number of infected farms was found in the towns of Burke, Sun Prairie and Windsor, with scattered infections in the towns of Cottage Grove, Deerfield, Westport, Dunn, Christiana, Bristol, Blooming Grove, Dunkirk, Pleasant Springs, and Madison. The inspection of fields outside these townships was

[1] This department is empowered by state law to apply measures necessary for the control or eradication of any new or dangerous plant disease.

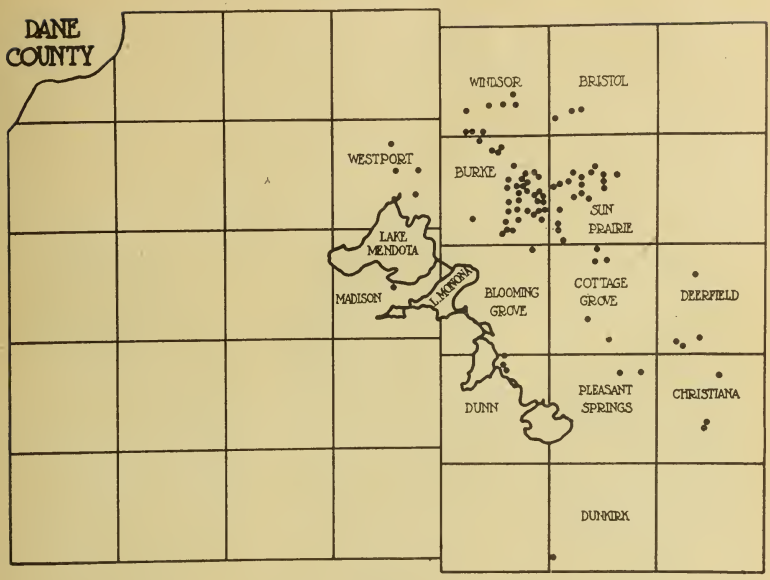


FIG. 1.—THE WILDFIRE INFESTED AREA IN DANE COUNTY
Each dot represents a farm on which wildfire was found in 1922.

complete enough to make reasonably certain that wildfire did not occur outside the area of these townships. Preliminary surveys, newspaper publicity, letters and other methods of inquiry indicate that all other tobacco-growing counties are apparently free from the disease.

The amount of infection varied from only faint signs of it to ten-acre fields in which practically every plant was infected up to the fourth or fifth leaf. The most severely infected fields bore no relation, however, to the center of the infected district. In practically every case field infection was traced to seed-bed infection. The seed used by the various growers had been obtained from widely varying sources and no relation of the seed to infection could be established.

On the basis of the survey the campaign of control and eradication was started early in July. State Department of Agriculture regulations regarding the control and eradication of wildfire were forwarded to owners of all infected fields. The first efforts at eradication were concerned with the removal of infected plants from the fields and replanting with healthy ones and destroying infected seed-beds. The most extensive work was cooperation

with the growers in removing and destroying infected leaves on farms where the disease was found too late for replanting. Half a dozen men were employed for several weeks in this way. After September 1, attention was given to the early plowing of infected

FIG. 2.—WILDFIRE STARTS IN THE PLANT-BEDS

The characteristic sign of wildfire is the yellow or bleached area around the center of infection. Watch your plant-beds for such signs on the young leaves.

fields, especially where infection started on the sucker growth. The control campaign is expected to be continued in 1923, particularly the inspecting of seed-beds and preventing the transplanting of infected plants.[2]

Signs of Wildfire in Plant-Beds

Wildfire may attack the plants at almost any stage of growth. On young plants it may resemble bed-rot, but the typical symptoms are quite distinct from other known diseases of tobacco. The most typical symptom in plant beds as well as in the field is a round, bleached or yellowish area (chlorotic area or halo).

[2] The survey and campaign for the control of wildfire was officially conducted by the State Department of Agriculture, the Experiment Station cooperating. The work of the control campaign can not be discussed in detail here, but the measures applied are essentially the same as those discussed under control measures in this bulletin.

This halo is sometimes as large as a dime and in the center is a dried area which often varies in size from a pin point up to a half inch in diameter (Fig. 2), with or without a distinctive yellow border, depending on the age of the spot and other conditions. The spots run together when numerous and may cause the whole leaf to collapse and dry up. In some seed-beds noted last spring the disease had practically destroyed all the leaves on the plants in the beds, leaving only the bare stems of the seedlings.

"Bud infection" is another symptom apparently not characteristic in other tobacco districts but fairly common in Wisconsin in 1922. In this case the young leaves surrounding the bud, and the bud itself, turned to a uniform light yellow color. (Fig. 3.)

FIG. 3.—BUD-INFECTION SOMETIMES OCCURS

The wildfire disease may affect the whole plant, with the result that it turns yellow in the bud and makes little or no further growth.

This symptom seems to result from the passage of toxic products from the infected areas through the plant to the bud, resulting in a bleaching similar to that characteristically localized in spots in older leaves. Plants so affected fail to make any growth or to recover. In some fields as high as 25 per cent of bud infection was noted. In such cases plowing under or removal of diseased plants and replanting the entire area was done. Where there are only a few cases of bud infection, infected plants should be removed and healthy plants res : in their places as soon as pos-

sible. As growers become acquainted with the signs of the disease, however, it is believed that infected plants will not be planted at all. This symptom occurred in the field probably only as the result of transplanting badly infected plants.

All infected areas in the seed-bed should be destroyed as quickly as they are noticed. It is quite unsafe to transplant even apparently disease-free plants from infected beds, and this should not be done if healthy plants can be obtained elsewhere.

Field Signs or Symptoms

Practically all wildfire infection in the field is traceable to infected plant-beds. While a few cases of seeming infection from field soil have been observed there is as yet no definite evidence that such occurs. The earliest field symptoms on young plants are, of course, about the same as those of the plant-bed, that is, leaf spots and bud infection. If infection has escaped notice, however, until the crop is one-half to full grown, some modification of the typical plant-bed symptoms may occur. While the bleached round spot with its central dead area (Fig. 4) is almost a sure sign of wildfire it is important to remember two more facts in field inspection. One is that wildfire spots sometimes occur without any bleached area surrounding them (Fig. 5), and consequently the disease is likely to be mistaken for ordinary "rust." The second is that at least one kind of "rust," the true "old-fashioned rust" of Wisconsin, also a bacterial disease, may show a fairly marked yellow area around the central point of infection when conditions are very favorable. By laboratory methods, however, all cases of true wildfire can be accurately determined.

The bottom leaves are most likely to show infection because they are exposed for the longest time and are in a better environmental position for infection. (Fig. 6.) Also, they are apparently more susceptible to the disease. Under favorable conditions for infection, however, the disease attacks with almost equal vigor the uppermost leaves, and even the suckers and seed pods. Cigar binder and wrapper tobaccos may become worthless by a comparatively few infections on a leaf, making it suitable only for stemming purposes. Heavily infected leaf ordinarily is not worth harvesting since the leaves are badly broken up in handling.

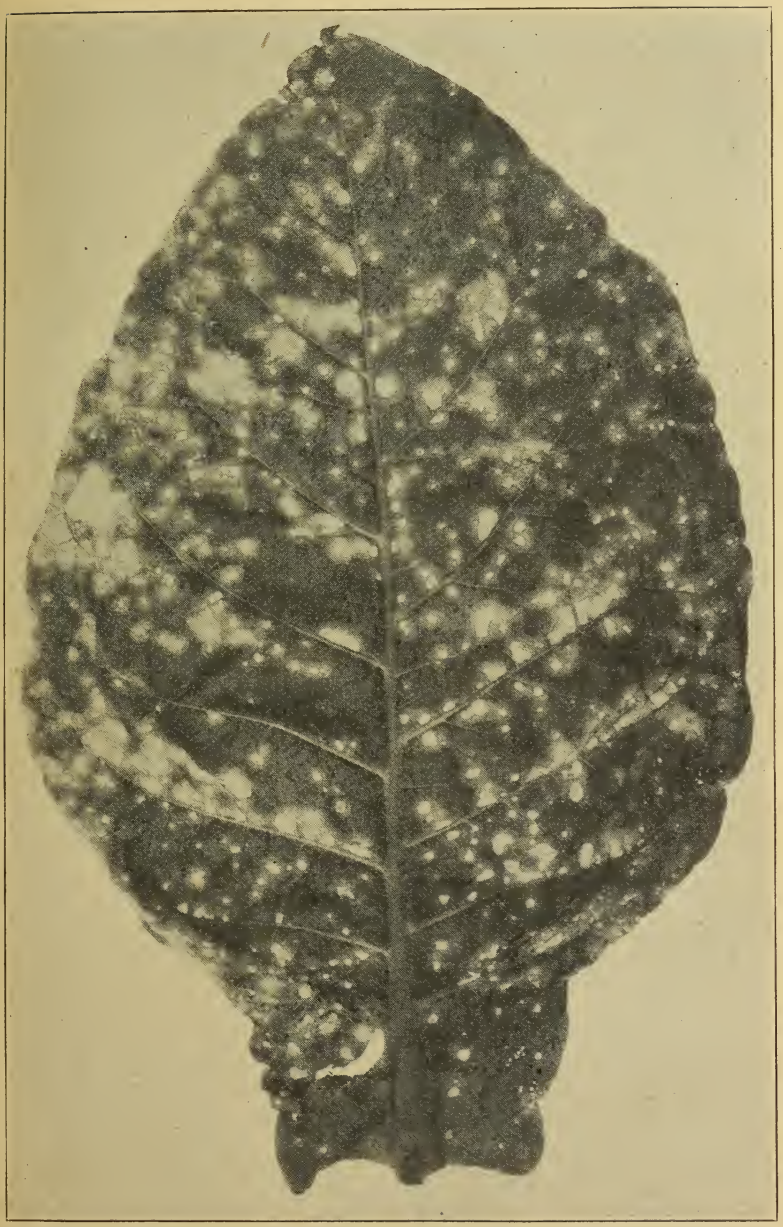


FIG. 4.—TYPICAL WILDFIRE IN FIELD

Fortunately infection is not always as heavy as here shown, but it is often worse under favorable conditions for the disease.

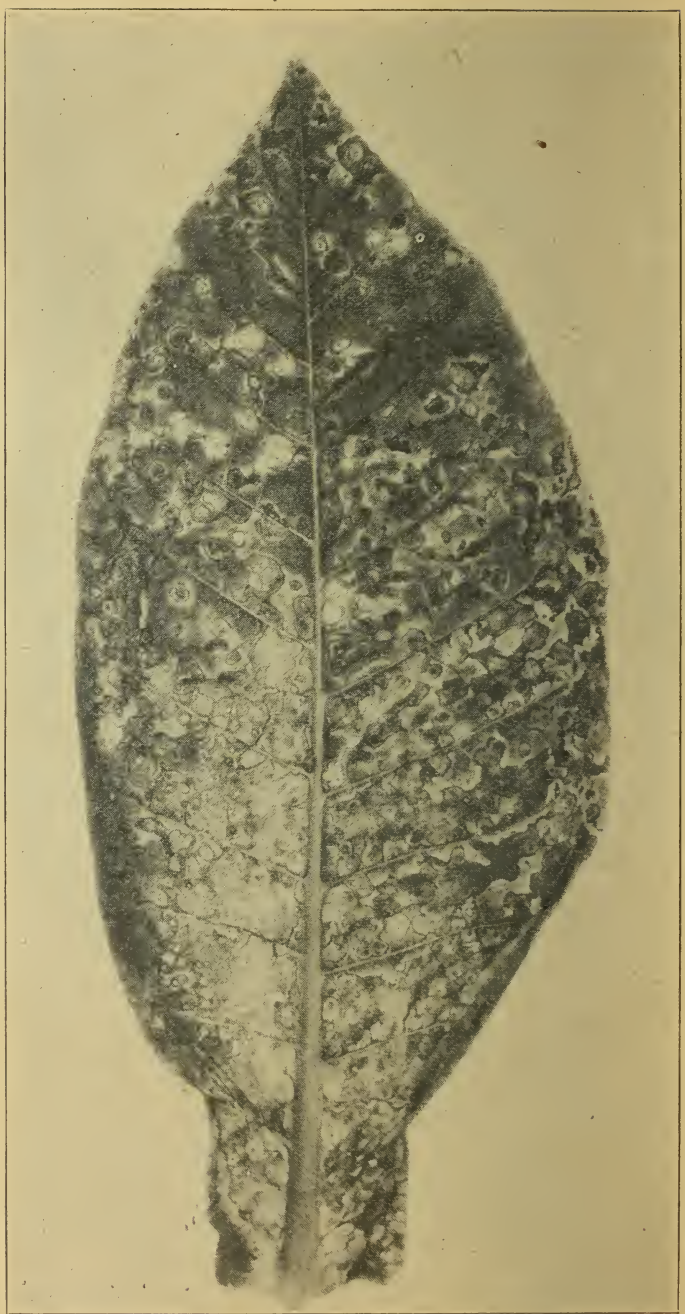


FIG. 5.—WILDFIRE, BUT NOT TYPICAL

Easily mistaken for ordinary rust. Little or no bleached area around spots, and these have run together and turned nearly the whole leaf to a brown color.

FIG. 6.—A FIELD INFECTED WITH WILDFIRE

Note the young spots on the upper leaves and the dried up condition of the lower leaves.

Cause of Wildfire

Most plant diseases are caused by microscopic organisms which infest and live on plant tissues. Different organisms cause different diseases and can often be recognized by the kind of decay or lesions they produce. Where such organisms are found, it is important to remember that the disease is infectious and hence may spread more or less rapidly, depending upon the vigor of the parasite, the susceptibility of the plants and the favorableness of the weather conditions for infection.

Wildfire is caused by a bacterial organism named *Bacterium tabacum*. Like all other bacteria this organism is extremely small and while one organism is enough to start a leaf-spot, hundreds of thousands of bacteria are eventually present in each spot and serve as new sources of infection. While this organism is very small it can be measured, photographed (Fig. 7), separated from all other organisms, cultivated and inoculated to healthy tobacco. The typical wildfire which it then produces absolutely proves it

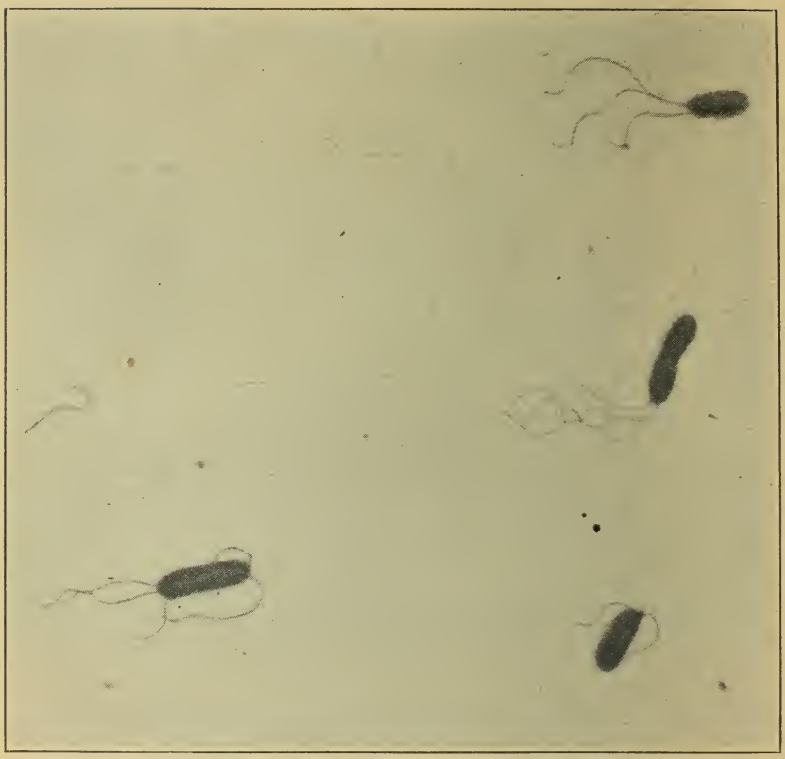


FIG. 7.—THE REAL CAUSE OF WILDFIRE

Photographed through a microscope, and enlarging to several thousand times their actual size, the wildfire bacteria look like short rods to which are attached "flagella" which enable them to move about.

to be the cause of this disease. (Fig. 8.) Without the wildfire germ it is just as impossible for the wildfire disease to occur as it is for a crop of corn to be produced in a field where no corn seed has been planted. Likewise, corn planted in dry soil fails to develop until sufficient moisture is supplied, and so while the wildfire organism may be present in great abundance rains are necessary for its development.

Conditions Favoring Wildfire

The worst periods of infection in Wisconsin in 1922 followed two separate storms with wind and some hail early in the growing season. Many growers, therefore, believed that the storm caused the "rusting" of their fields, and found it difficult to accept

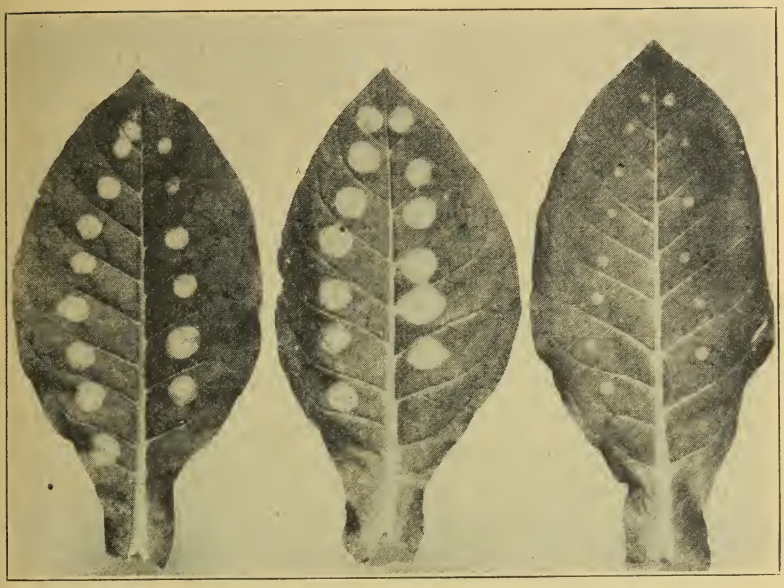


FIG. 8.—THE DISEASE CAN BE PRODUCED AT WILL

The bacteria when placed on tobacco leaves in a drop of water produce spots of the same type as found under natural conditions.

the infectious nature of the disease, although many neighboring fields showed the effects of the storm but did not have wildfire. Storms, especially beating rains, however, have a very important relation to wildfire in that they favor infection to a high degree. The bacteria are often unable to infect the leaves except through slightly wounded tissue, such as may be produced by beating rain, although with rapidly growing tobacco, moisture in itself often suffices for considerable infection. The facts are, generally, that heavy infection and damage practically depend upon storms or continued rains. This does not alter the conclusion, however, that wildfire damage is first of all dependent upon the presence of bacterial organisms and that the control of the disease must depend upon preventing the general introduction of these bacteria into the seed-beds and fields.

Wildfire Compared With Other Rusts

The name "rust" is a very general one used by tobacco growers and includes many different leaf-spots due to as many different and distinct causes. The characteristics of the more common ones are as follows:

Ordinary or "old-fashioned rust" is quite similar to wildfire, but is due to a different bacterium which is much less serious and rare in its attacks on tobacco. The spots are ordinarily brown and show a less distinct, if any, yellow area around the center of infection. (Fig. 9.) The yellow area, or halo, is, on

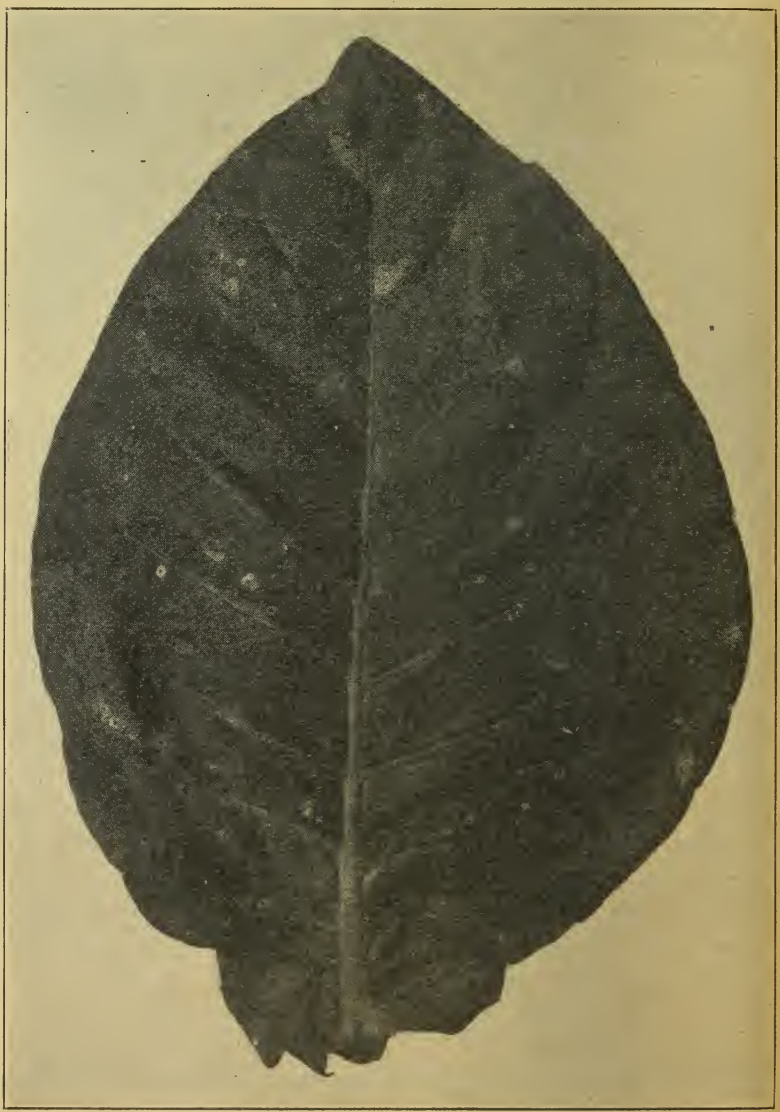


FIG. 9.—ORDINARY WISCONSIN "RUST"

This disease looks much like wildfire, but it is caused by another species of bacteria which is not nearly as apt to cause large losses as is wildfire.

the other hand, quite typical of wildfire. Ordinary rust occurs rarely, usually only on small parts of the fields, and does not spread easily and as far as known never destroys plants in the seed-bed as wildfire does.

"Mosaic rust" or "firing" was very common and serious in Wisconsin in 1922. White or brownish spots occur on the leaves and in more severe cases large patches of the leaves turn yellow or brown and dry up. (Fig. 10.) This disease is readily

FIG. 10.—MOSAIC "RUST" SOMETIMES MISTAKEN FOR WILDFIRE

This disease was common in Wisconsin in 1922. The ordinary symptoms of mosaic are shown in the two upper sucker leaves, the lower ones being healthy leaves.

recognized by the mosaic symptoms on the young leaves or suckers. The mosaic disease, itself, is indicated by leaves mottled green and yellow and often deformed. The plants are weakened as a whole and under certain weather conditions, rusting or

"firing" occurs. Commonly, no great damage is done by this disease in Wisconsin, although more or less of it can be found every year.

Non-parasitic leaf-spots or non-infectious rusts not due to germs but resulting rather from unfavorable soil conditions for tobacco, make up a third class. (Fig. 11.) They are fairly common on some soils with certain types of tobacco, and often manifest themselves in several different types or forms of spots. These spots are usually not numerous enough to cause much concern.

Many other leaf-spots or rusts occur throughout the country but are very uncommon or not known to occur in Wisconsin.

How Does Wildfire Live Over Winter?

For practically six months the wildfire germ must maintain life in some manner without any living plants upon which to feed and multiply. While there is evidence that some of these germs can live for several weeks under very unfavorable conditions as on dried leaves, seed, cloth and so forth, yet their number is reduced very rapidly. It seems, however, that a few of the germs must survive in some manner for the six-month period, probably because of being lodged in some especially favorable situation for maintaining life. If the only manner in which the disease overwinters could be determined it might greatly simplify present methods of control.

Bacteria may live over winter in a wide variety of ways, but in the case of wildfire it is difficult to find out how this is done even with the aid of practical observation and experiments. It seems likely that under certain conditions the bacteria may live over winter on the seed, but that this is not in all cases true seems evident from the data gathered on the source of seed of infected seed-beds this past season in Wisconsin. Some suspicion also falls on seed-bed covers, seed-bed frames, soil, cured tobacco leaves, tobacco refuse from sheds, tobacco stalks or any other material or equipment that may come in contact with wildfire and subsequently with tobacco plants in the spring.

It is necessary, therefore, in preparing the seed-beds in the spring to use all possible precautions to prevent infestation with wildfire on farms where wildfire has previously occurred.

FIG. 11.—ANOTHER TYPE OF RUST

These spots are different from any of the others mentioned in that no germs are concerned, but they develop rather from a combination of conditions in the soil and plant itself.

Spread of the Disease

Once infection has occurred in the spring it is not difficult to see how the disease may spread in the seed-bed, in the field and from field to field. In addition to being carried through the air under certain conditions, men, animals and tools or other equipment may carry it in various ways through the field or from field to field unless proper care is taken. The disease is most easily spread when the tobacco is wet and at such times it is a good plan to remain out of the fields when the plants have reached some size.

The transfer of infected plants for transplanting is the most evident means of spreading the disease from farm to farm and should by all means be avoided. In general the greatest injury seems to be done by an upward spread on the plants from infected lower leaves so that the greater the number of infected plants the greater the damage from the disease. On the other hand, under favorable conditions for the spread of the disease, as during driving rain storms, general spread in the direction of the wind takes place and a relatively few infected plants in the field may cause general infection to occur later. When infection has once occurred in the field, therefore, and entire replanting is not resorted to, it seems practical in many cases to break off and destroy the infected leaves and hence reduce the spread which may follow stormy or rainy periods.

Control Measures

From the foregoing discussion the possible measures for the control of wildfire are evident. The practicability of the control measures vary, however, with conditions. If, for example, most of the leaves on a half grown crop are infected, it would be impractical and too expensive to remove these leaves from stalk-cut tobacco with the purpose of profiting by reducing the infection in the remainder of the single crop. Until more experimental evidence is at hand, however, the grower may need to go to some unnecessary trouble to make certain that everything possible is done to avoid unlimited spread. This is especially important while there may still be a possibility of eradicating the disease from the state, or preventing its spread to uninfested sections.

The control measures recommended are largely concerned with growing disease-free plants in the seed-beds. If this fails healthy plants should be sought elsewhere. If diseased plants are accidentally set out the infected plants and leaves should be destroyed as soon as possible, if the infection is light and scattered. In case of general infection found before July 1 it is advisable to destroy and replant entirely. These efforts are not only for the purpose of reducing as much as possible the chances of the present crop being damaged by wildfire, but also to prevent the accumulation of infected material on the farm which serves as a source of infection for next year's crop on the same farm and vicinity.

Precautions to Prevent Infection in Seed-Beds

On farms where wildfire has once occurred the grower should take these precautions to reduce the danger of introducing wildfire into the plant-beds:

1. Locate beds a considerable distance from where tobacco beds or fields were located last year and away from tobacco sheds.
2. Do not use refuse from tobacco sheds or stripping room as fertilizer in seed-beds or field, but preferably rake it up carefully and destroy before the beds are started.
3. Use new frame boards or disinfect old boards by sprinkling or painting with some disinfecting solution such as 1 part of formalin to 25 parts of water.
4. Use new seed-bed covers, or sterilize old covers by boiling one hour.
5. Use seed known to come from uninfested districts or seed which has been disinfected. Seed may be treated most safely by using corrosive sublimate (1 part to 1,000 parts of water) into which the seed contained in a cheese-cloth bag is dipped for 10-15 minutes. Rinse thoroughly with pure water and dry as rapidly as possible.[3]
6. As a final measure the grower may have to resort to spraying or dusting the beds with Bordeaux mixture if the disease becomes sufficiently serious to warrant it in spite of all other precautions. Spraying or dusting should be done once a week from the time the leaves are as large as a dime until

[3] Corrosive sublimate is a strong poison but will not affect the hands. It corrodes metal and for that reason a glass or wooden vessel should be used for holding the solution. It can be purchased at drug stores in convenient form.

the pulling of plants is completed. Such treatment has been found to be efficient in preventing heavy spread of infection throughout the beds. More detailed information on this subject will be furnished upon request to the Experiment Station, Madison, or State Department of Agriculture.

Do Not Transplant Infected Plants

Where wildfire infection is found in seed-beds the diseased areas and those bordering them should be destroyed at once as completely as possible. Weeding and pulling plants will especially spread the disease over large areas of the bed. The infected areas can best be destroyed by drenching with formalin (1 part to 25 parts water) and covering with some material to hold the fumes, or by cutting the plants and sprinkling the areas with kerosene and burning over. In case no further signs of the disease are evident it is fairly safe to use plants from other parts of the same beds, but plants should preferably not be pulled from within several feet of the infected areas. To be entirely safe, plants from such beds should not be used at all.

Best Methods in Case of Field Infection

When wildfire is found in the field the best procedure will depend upon the amount of disease present and the time of the season when it was first observed. If a large percentage of the plants show infection before July 1 in Wisconsin the safest thing is to destroy the planting by plowing under or pulling out all the plants, refitting the ground and replanting from healthy beds. While this method is tedious and expensive and involves the possibility of damage by frost to a later crop, it is no more discouraging than working with a crop badly damaged by wildfire.

If infection is noted on only a few plants early in the session, pull them out, carry them off the field, burn or bury them, and reset healthy plants in their places.

After July 1 planting is not ordinarily desirable and it is usually just as well to take the chance that the disease may be checked during the season by unfavorable weather conditions, together with what may be accomplished by removal of infected leaves. During the first month the tobacco is in the field serious effort should be made to remove all infected leaves, even though this means much tedious labor and expense. Even if infection

gets such a start that two to five leaves are involved on practically every plant, this measure may be profitably adopted as part of an eradication policy in place of complete destruction of the crop.

Destroy Second Growth of Suckers

Wildfire will also attack sucker growth on harvested fields in the fall if the weather is favorable. This is an additional and unnecessary possible source of infection for the farm and community. Plowing under the suckers before they make much growth will effectively prevent this danger. Fall plowing is in any case desirable as a rule from a general agricultural standpoint. Fields on which wildfire has occurred should preferably not be used for tobacco culture the following year, although it is not generally regarded as unsafe to do so.

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UNIVERSITY OF ILLINOIS
APR 10 1923

Make Alfalfa a Sure Crop

AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF WISCONSIN
MADISON

THE STORY TOLD BY THE COLORED PICTURES

(See Center Page)

Early Cutting Weakens Alfalfa

For permanence, yields and the elimination of weeds alfalfa should be cut as near the full bloom stage as possible without allowing the hay to become too coarse. Cutting at early stages weakens the succeeding growth, causes yellowing and reduces the yields.

Lime or No Lime

The alfalfa in the foreground growing on sour soil without lime is thin, weak, yellow and sickly. Where lime was applied the heavy rich, dark green growth occurred. This demonstration proof of the value of lime brought about the use of several thousand tons of ground limestone for more and better alfalfa.

Low Areas Winterkill

Even the hardiest strains of alfalfa may winterkill on the low areas where water accumulates and ice sheets form. Choose a sloping soil.

Old Seeding Winterkills; New Seeding Not Injured

New seedings are much hardier than old stands. The new alfalfa in the background did not winterkill, but the four-year-old alfalfa in the foreground has succumbed to the rigors of a hard winter and has been largely replaced by grasses. New seedings are not apt to winterkill if well established with hardy alfalfa. A new stand started every year or two is one way to guard against a total loss from winterkilling.

Hardy Common; Weak Common

In trials with alfalfa from common seed grown in New Mexico and Arizona, as shown in the foreground, it was found that these strains were generally more susceptible to winter injury than common strains from the more northern states such as South Dakota, Nebraska and Montana.

Make Alfalfa a Sure Crop

R. A. Moore and L. F. Graber

ALFALFA is one of the most profitable crops that can be raised on the average Wisconsin farm. It excels all other Wisconsin hay crops in yields by an average of one ton of hay an acre. It is far more drought-resistant than any of the clovers or timothy and especially is this true of new seedings. It builds up the soil; maintains fertility;

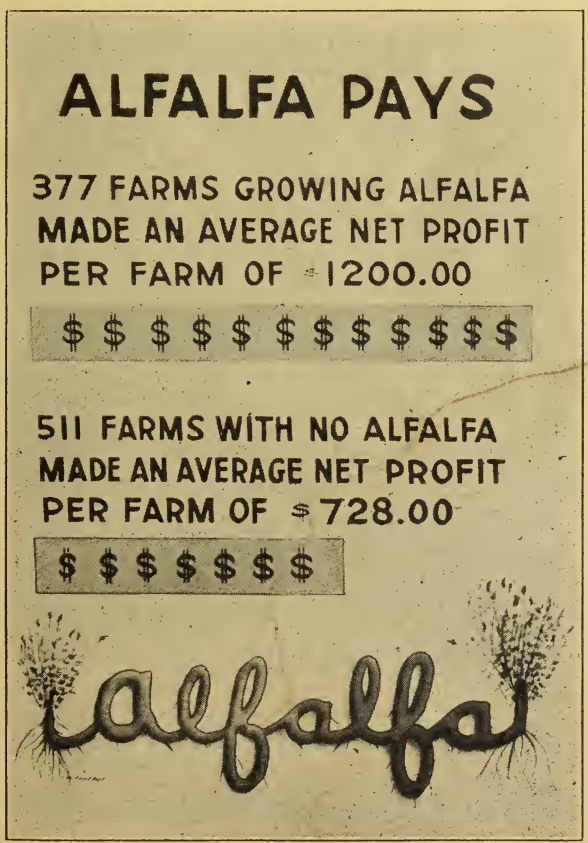

FIG. 1.—PROOF OF PROFITS.

An investigation made several years ago by the Wisconsin Experiment Station where financial records were kept on 888 Wisconsin farms indicates that the alfalfa growers made the most money.

eradicates the worst of weeds such as Canada thistles, morning-glories, and numerous others less serious; and at the

FIG. 2.—WHY ALFALFA STANDS DROUGHT BETTER THAN CLOVER

The deeper tap root growth of alfalfa seedlings (1) as shown above compared to the shallower spreading type of roots for red and alsike clover seedlings of the same age (2) explains how alfalfa under favorable soil conditions is often a surer crop than clover because of its greater ability to secure moisture out of the soil in times of severe drought.

same time furnishes a great abundance of very rich feeding hay for our livestock. It can be grown on the light sandy soils and the heaviest clays.

While the market value of western alfalfa hay in the stack may range from $4 to $8 a ton, the cost of transportation, baling and loading this bulky product brings the price from $20 to $30 a ton f. o. b. Wisconsin points. This protects

home-grown alfalfa from competition with the surplus alfalfa produced in the western states and accounts for market prices which have always been sufficiently high in Wisconsin to warrant the most profitable use of liming, fertilization, and inoculation—which are so often necessary to make alfalfa a success.

New Seedings Reduce Winterkilling

While winterkilling has at times been serious, yet these losses can be quite largely controlled by the avoidance of late fall cutting and pasturing; by the use of hardy strains of seed and the frequent establishment of new seedings of alfalfa as a part of the regular farm rotation. A new stand of hardy alfalfa will generally weather the worst winters; and not infrequently new seedings of the average northern common will survive when older stands of the same strains are practically killed out. The farmer who has soil well supplied with lime and

FIG. 3.—CANADA THISTLES IN AN OAT FIELD

The worst patches of Canada thistles and morning-glories are being eradicated where good vigorous stands of alfalfa are established.

inoculated so that in a crop rotation he may seed alfalfa every one or two years will find that after a hard winter the old seeding may kill, but the new seedings nearly always remain and prevent total loss of his hay crop.

FIG. 4.—ALFALFA ENRICHES SOIL

(1) Blue grass from an eight-year-old alfalfa field partly winter-killed compared with an average sample, (2) taken from an adjacent seven-year-old blue grass sod containing no alfalfa

FIG. 5.—GROWTH OF BUCKWHEAT ON ALFALFA AND BLUE GRASS SOD

Both the blue grass and alfalfa sods in Fig. 4 were plowed and seeded to buckwheat early in July. After three weeks growth, sample (3) shows twenty average plants from the alfalfa sod, and (4) twenty average plants from the blue grass sod.

Hardy Strains For a Stand That Will Last

While such varieties as Grimm often live through hard winters where the average common kills out, there are many farms where common seed grown in the Dakotas, Montana and other northern states has given fairly good results.

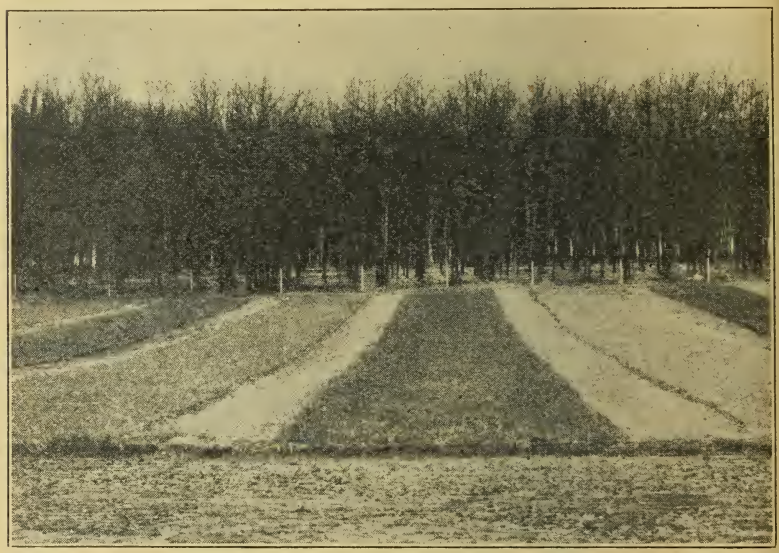

FIG. 6.—AFTER SEVERE WINTERS HARDY STRAINS MAKE MORE RAPID GROWTH

Note vigorous early spring growth of Grimm and other hardy strains of alfalfa after a hard winter compared with western common strains on either side which were so badly weakened that they have scarcely begun to grow.

This is especially true where winterkilling has not been serious and where alfalfa is used in rotation and permanent stands are not particularly desired. Grimm is by no means winter proof and it is just as hard to get a stand established as it is of common, but with a field of good hardy Grimm once well started, it may last much longer and probably there will be less blue grass difficulty. The hardy varieties are high priced and caution may well be used to secure the hardiest strains of carefully certified seed. Unless the soil is in condition to produce a stand with a reasonable degree of certainty, it may be wise to use the cheaper, common, northern-grown seed.

Southern-grown alfalfa seed from such states as Arizona, New Mexico and Utah has produced stands very sensitive to unfavorable Wisconsin winter weather.

Lime Is Alfalfa's Greatest Need

It is easy to throw away time, labor, seed, and money by trying to grow alfalfa on sour land without the use of ground limestone or some other suitable form of lime. Alfalfa is a lime-hungry plant, requiring nearly 100 pounds of lime to make a ton of cured hay. Lack of lime in the soil has been the cause of thousands of failures with alfalfa. Take no

FIG. 7.—ALFALFA BEST HOG PASTURE

For a period of 5 years (1916-20) alfalfa excelled all other hog pastures in profitable pork production at the Wisconsin Experiment Station.

chances on that soil of yours. Find out if it needs lime. Have it tested by your county agent or the Experiment Station*. If your soil is very sour and requires from three to five tons of ground limestone an acre, do not grow alfalfa until you can apply the necessary lime. Your soil may have enough lime to grow good corn, oats, timothy, and alsike clover, but that does not indicate there is sufficient lime in the surface six inches to get alfalfa well started. Use lime if your ground needs it.

*If you have no county agent, take a half-pound sample of soil from five or six average places in the surface of the field and send it to the Experiment Station, Madison, Wisconsin, with a letter asking for an acidity test.

If You Cannot Get Lime

Many farmers live from four to ten miles from a railroad station. If they happen to be in a region where lime rock is abundant, and where the soil is of a clay, loam or silt character, (not sandy), there is some chance of starting a permanent field. First of all, the soil must be tested. If it is sour, so as to require three or more tons of ground limestone an acre, it is better to leave alfalfa alone until the lime can be supplied. But if only one or two tons are necessary and the soil is rich, or well manured, there is a fair chance to grow

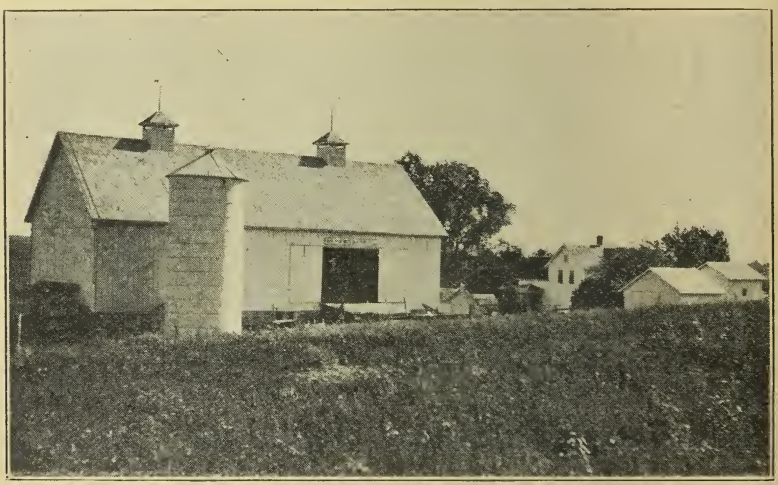

FIG. 8.—ALFALFA FOR HAY; CORN FOR THE SILO
For home grown feed this combination is hard to excel either in yields or quality.

alfalfa without supplying lime, provided you will not expect too much from the first crop. The older alfalfa becomes the deeper the roots penetrate the subsoil, where they may often obtain sufficient lime for a strong, healthy growth. This partly explains why some farmers find their alfalfa rapidly improves with age. Try this mixture at 20 pounds an acre:

14 pounds alfalfa seed
2 " alsike "
4 " timothy "

If on account of a lack of lime in the surface soil the alfalfa is yellow and weak in spots at the time of the first cutting, the alsike and timothy will help fill in the thin places and

hold up the yields. The second and third growths will generally be pure alfalfa—stronger and healthier than the first crop because the roots become more and more established in the subsoil where they may find sufficient lime to produce heavy yields.

If winters are favorable, the alfalfa plants grow larger and larger. They spread out and gradually replace the alsike as it dies out. This plan is well worth trying, but leave out the clover if your soil will produce a heavy volunteer growth of alsike without sowing any seed. Where soil conditions are not entirely favorable, sow alfalfa with early oats or pedigree barley and cut the grain for hay. Early removal of the nurse crop will guard against summer's drought and helps to insure a good stand.

Home Ground Limestone

In many parts of the state there are abundant outcroppings of limestone of a very high quality for soil improvement. To those living at considerable distances from freight stations "the haul" of "shipped-in" limestone is a great expense and

FIG. 9.—GRINDING LIME ROCK AT LOCAL QUARRIES

Farmers living at considerable distances from railroad stations in some counties are eliminating long hauls by having operators of portable grinders pulverize limestone rock for them at local quarries or limestone fences.

inconvenience. In some places high-testing lime rock is ground for the farmer by private operators at a quarry on or near the farm at a flat price which eliminates the long haul and may result in a tremendous financial saving. In three years over 8,000 tons of lime were ground on this basis in Green county alone. The idea has spread into numerous other counties, as Iowa, where in two years, 6,000 tons were ground; in Rock county where four machines are operating with an annual production of 7,000 tons; in Green Lake county where one grinder has produced 2,000 tons in six months. In many other counties the plan is just being initiated.

How to Lime

Ground limestone can be spread with a shovel, with manure spreader, or with a lime distributor.

Always apply lime to the surface of plowed land—never plow it under.

FIG. 10.—SPREADING GROUND LIMESTONE WITH A MANURE SPREADER

This is a convenient way to apply the lime. Regular distributors some of which are in the form of end gate spreaders may be used or the limestone can be spread by hand with a shovel.

Autumn is probably the best time to apply lime, but winter or early spring are often convenient and satisfactory periods for putting agricultural lime on the land.

WEAK
COMMON
OLD
SEEDING
WINTERKILLED

LIME
NO LIME
HARDY COMMON
WEAK COMMON
TOO EARLY CUTTING
MAKES NEXT CROP
SHORT - WEAK - YELLOW
CUT IN FULL BLOOM
MAKES NEXT CROP
HEALTHY - STRONG - VIGOROUS
LOW AREAS WINTERKILLED
NEW SEEDING NOT INJURED
OLD SEEDING WINTERKILLED

Inoculate for Vigorous Growth

Where alfalfa has not been grown successfully before, either the seed or the soil should be inoculated. Why take the risk? Cultures, which can be gotten through your county agent or Experiment Station, may conveniently be applied

(1) Alfalfa Nodules (2) Alfalfa Bacteria

FIG. 11—"FERTILIZER FACTORIES" ON ROOTS OF ALFALFA

The little white swellings or nodules on alfalfa roots are sure indications of proper inoculation. They are the homes of millions of alfalfa bacteria which gather nitrogen from the soil air and convert it into an actual growth-producing fertilizer for the alfalfa plants.

to the seed just before sowing. Inoculation is nothing more or less than a simple, easy, and inexpensive process of introducing into soils the real fertilizer manufacturing bacteria which develop swellings and nodules on the alfalfa roots and make the plants strong, healthy and vigorous.

Give Alfalfa a Square Deal

Alfalfa requires nothing in the way of soil treatment but what is largely needed to produce the most abundant yields of corn, small grains, and other crops.

Play safe. Get inoculated with the right ideas about growing alfalfa. Sow alfalfa right or don't sow it at all. Give it a square deal if you expect a square deal in return.

Get the Nurse Crop off Early

Many a good stand of alfalfa and of clover is ruined by the summer's drought. Grasshoppers are very serious in some years. There is a way to play reasonably safe on this. Sow your alfalfa with one bushel of early ripening grain an acre, such as Kherson, (Wis. No. 7) oats or pedigree barley. Cut this grain for hay just after it is headed out. This saves soil moisture and gives the alfalfa a good growing start to stand later summer drought as well as grasshopper injury. Cutting the nurse crop for hay is not always necessary, but is essential when grain lodges, otherwise alfalfa may smother.

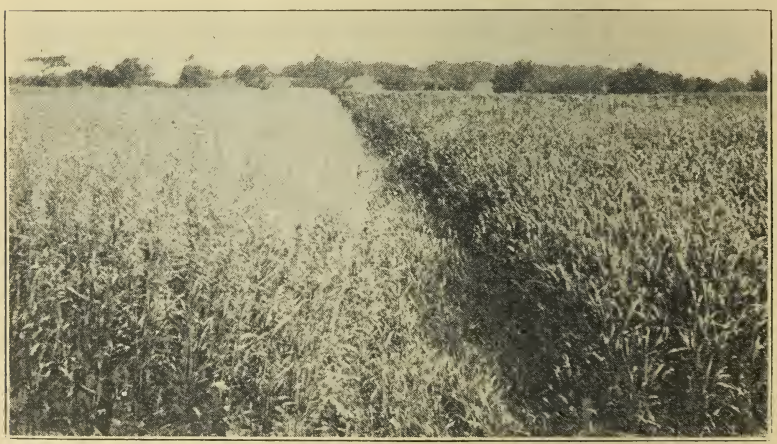

FIG. 12.—EARLY RIPENING NURSE CROPS INSURE GOOD STANDS

Such early ripening grains as Kherson (Wis. No. 7) oats (at left) and pedigree barley are far more preferable than late maturing oats (at right) or spring wheat.

This method is especially advised when high-priced alfalfa seed is used. With this plan you take little chance of failure if your soil conditions are right or nearly so. Compare this method with that of sowing alfalfa with late oats or late spring wheat, which take huge quantities of moisture from the soil during the ripening process and are usually cut at the beginning of our hottest and driest weather. Canning peas make an excellent nurse crop because they are cut and

hauled off the land early. Other methods can be used, but late summer or fall seeding should be avoided in Wisconsin.

FIG. 13.—CUT LODGED GRAIN FOR HAY

Early removal of the nurse crop for hay, especially in case of lodged grain, is an important step towards success in establishing a good stand of alfalfa.

Select Reasonably Rich Soil

It is a waste of time and money to attempt to grow alfalfa on a worn-out piece of ground unless the soil is abundantly supplied with lime. If your land is not rich and fertile, put on a good dressing of manure. In many instances phosphate fertilizer helps immensely.

Lime, inoculation and manure.

Make alfalfa doubly sure.

Use Clean Ground

To avoid weed trouble, have your alfalfa follow some well-cultivated crop like corn or potatoes. If weeds, especially foxtail, become thick the first season, cut them close to the ground, prior to August 15. Use a mower or grain binder. Haul the cut weeds off the field, especially if there is a heavy growth. A fairly heavy sprinkling of weeds will probably cause very little harm and if not cut may prove a splendid winter protection. Cutting or clipping is not always necessary or advisable.

Avoid Flat Land

If you have a heavy flat soil with a hardpan subsoil, or a tight blue or red clay subsoil that does not permit good under-drainage, leave alfalfa alone. You will have better luck with timothy and alsike. Alfalfa must have good surface and

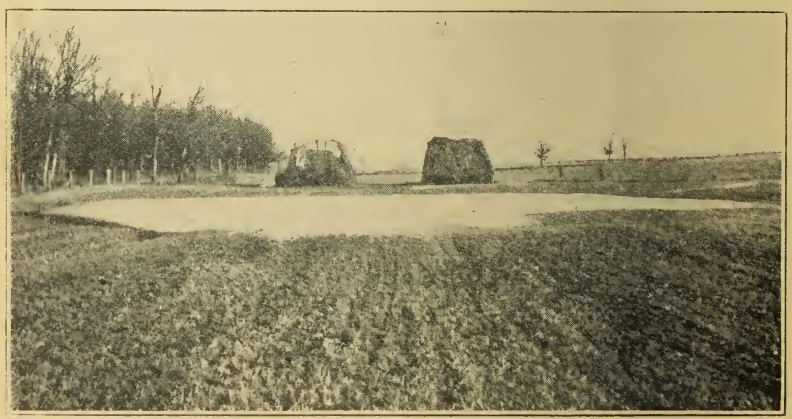

FIG. 14.—BEST TO CHOOSE A SLOPING FIELD

Flat lands will grow alfalfa but smothering ice sheets like this may cause winterkilling especially if the under-drainage is poor.

under-drainage. It likes a gravelly limestone subsoil best. Sometimes it grows remarkably well on rich bottom lands or on black flat prairie loams and flat sandy soils that have good thorough under-drainage, but in certain years it will suffer most severely from ice sheets and other winter injury on any flat ground. Choose a sloping soil.

Rolling Helps

Alfalfa wants a firm but well-prepared seed bed. Fall plowing is best with the heavier soils as it gives the soil time to settle and become firm. Spring plowing should be comparatively shallow. Alfalfa sown on spring plowed land—especially loose sandy soils—is greatly benefited by rolling

FIG. 15.—ROLLING MAKES A SPLENDID SEED BED

The corrugated roller breaks coarse lumps, firms the seed bed, and leaves the surface loose. It is often desirable to roll both before and after seeding.

with a corrugated roller. It helps clover also and brings better yields of grain. The corrugated roller is a much needed implement on many farms. Alfalfa wants a firm seed bed with the lumps on the surface well broken up. The corrugated roller will do this and do it well. Rolling before and after seeding is advisable

Use Enough Seed

If your land has plenty of lime, an open gravelly subsoil, and grows alfalfa easily, 15 pounds an acre of clean seed that germinates 90 per cent or above is sufficient. If you are sowing alfalfa for the first time or if your soil is not particularly well adapted to alfalfa growing, it is better to use 18 to 20 pounds, especially where common seed is used.

Timothy With Alfalfa Keeps Out Weeds and Blue Grass

Timothy grows surprisingly well with alfalfa. The first crop is ready to cut just when the timothy is in early bloom and at that stage it is quite palatable and digestible. The

FIG. 16.—HOW TIMOTHY HELPS WHEN ALFALFA WINTERKILLS

Mixing a little timothy with alfalfa insures against total loss when winterkilling occurs. Two seven-year-old alfalfa plots, one seeded with timothy and the other alone, winterkilled almost completely. The timothy mixture gave a yield of 2.4 tons of hay an acre made up of a mixture of a few spears of alfalfa, 95 per cent timothy and 5 per cent blue grass. Where alfalfa was seeded alone the plot gave 1.2 tons of blue grass hay containing about 10 per cent alfalfa.

second and third growths will generally be pure alfalfa. But the important point is: Suppose the alfalfa should winter-

kill or become thin in spots? Instead of weeds and blue grass coming in you are likely to find that the timothy thickens right up; and the way it grows on the dead rotting roots of alfalfa is most remarkable. Where the alfalfa remains thick the timothy will be comparatively thin and where the alfalfa thins the timothy thickens. The two crops go hand in hand to maintain a good stand. Timothy helps keep out blue grass and increases the yields. Try this at least in a small way, mixing one-fourth or one-fifth timothy by weight with your alfalfa and sow the mixture 20 pounds an acre. The chief objection to this combination has come from those who are loathe to use even good timothy as part of their ration for dairy cattle and who secure splendid uniform stands of alfalfa with great ease under their particular soil conditions.

Mix Alfalfa With Your Grass and Clover Seed

It is excellent practice on most farms to mix in with the regular timothy and clover seedings from two to four pounds of alfalfa seed per acre. Inoculate this seed before mixing and you will soon have your whole farm inoculated for future crops of alfalfa. Alfalfa growing with timothy and clover improves the yield and quality of hay. Even if your ground is a little sour, a thin sprinkling of alfalfa plants will generally get sufficient lime for a strong, healthy growth.

How to Avoid Blue Grass Troubles

Do not cut or pasture your alfalfa after the first week in September if a permanent stand is desired. It does not pay to kill the goose that lays the golden eggs by trying to get an extra crop late in the fall. Alfalfa needs a growth of fully eight inches or more for protection against winter-killing.

FIG. 17.—PASTURING NEW SEEDINGS A POOR PRACTICE
Fall pasturing new seedings may result in winterkilling and thinning of the stand.

Proper Cutting Stage of Alfalfa

Two crops of alfalfa cut in the full bloom stage often yield as much, and not infrequently yield considerably more hay

FIG. 18.—LATE FALL CUTTING AND PASTURING CAUSE WINTERKILLING AND BLUE GRASS TROUBLES
The left part of this field which is so badly winterkilled and overrun with blue grass was cut the previous fall on October 12. The alfalfa on the right was last cut on August 30, the previous year, and came through the winter uninjured. In the northern states cutting or heavy pasturing after the first week in September is poor practice.

than three crops cut in the early bud or tenth bloom stage. Of course, the later you cut alfalfa the coarser and poorer the

quality of hay, but too early cutting weakens and thins out alfalfa, while later cutting strengthens the plants against winterkilling, weeds, low yields and blue grass. With favorable weather, alfalfa should be cut for hay as near the full bloom stage as possible without sacrificing too much on the quality of hay. Especially is this essential following hard winters. One-year-old alfalfa grows less luxuriantly and generally can be cut in the full bloom stage without serious reduction in the quality of the hay and with considerable increase in the total yields. Although the shoot development of alfalfa has long been used as a gauge for the proper

FIG. 19.—TALL ALFALFA STUBBLES HELP TO HOLD SNOW

There is no better winter protection than a good covering of snow. A good fall growth of alfalfa strengthens the roots, prevents ice sheets from forming close to the ground and keeps the snow from rapidly melting or blowing away—all of which guard against winter injury.

cutting stage, experiments at the Wisconsin Experiment Station indicate that the clipping of the more advanced sprouts is not injurious to the succeeding growth. This is of importance for those who are raising alfalfa seed. While in certain seasons three hay crops may be obtained, many experienced growers get the biggest yields in the long run by cutting only twice a year, leaving a tall heavy growth for winter protection.

How to Grow Alfalfa on Sandy Soil

Sandy soils which grow potatoes successfully can usually be made to produce good crops of alfalfa. Remarkable growths of alfalfa have been secured on light sandy soils which have been properly treated.

FIG. 20.—ALFALFA IS THE PREMIER HAY CROP FOR SANDY SOILS

Because of its great drought resistance, alfalfa is the best permanent hay crop for sandy land. Lime, manure, and inoculation produced the above excellent crop (second growth) on a light sandy soil near Plainfield, Wisconsin.

Six Sandy Soil Suggestions—

Lime is the first essential.

Inoculate for better yields.

Apply manure or commercial fertilizer or both.

Roll with corrugated roller just before and after sowing.

Seed with a light sowing of early spring grain which should be cut for hay just as it heads out or use no nurse crop at all and sow the alfalfa in the latter part of May after the soil has been freed of weeds by previous cultivation.

FIG. 21—INOCULATION OR STARVATION

Each jar contains pure quartz sand to which all the necessary elements for plant growth, except nitrogen, have been added. The alfalfa bacteria supplied by inoculation have taken sufficient nitrogen from the air to produce a healthy growth of alfalfa. The alfalfa plants in the sand receiving no inoculation have starved for a want of nitrogen. Inoculation is very important especially on sandy and other soils, which may lack nitrogen.

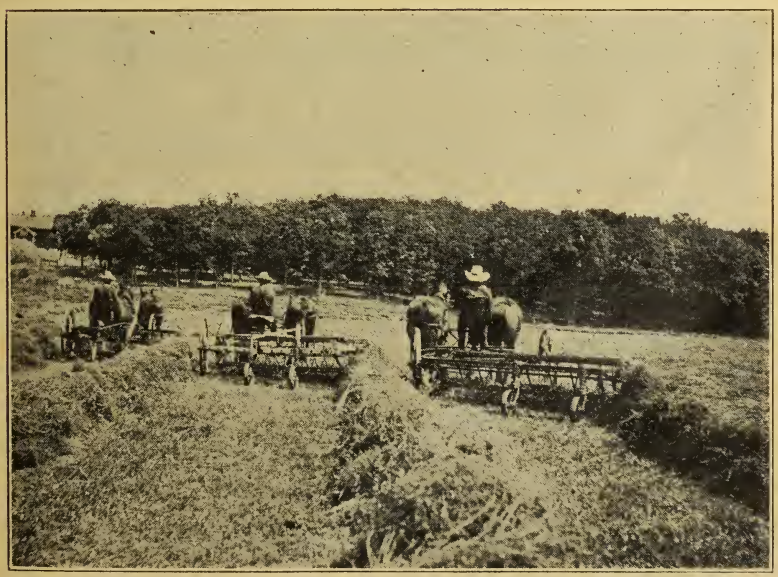

FIG. 22.—CURING IN WINDROWS SAVES LEAVES

Alfalfa hay is readily raked into windrows with side delivery rakes and can be loaded with hay loaders

Raising Alfalfa Seed in Wisconsin

Several growers in the eastern part of the state have grown alfalfa seed very successfully. In one county alone over a thousand bushels of seed were grown in 1921. The second crop generally is taken for seed and if the dry weather occurs during the blossoming period yields of from two to four bushels an acre have been obtained. If the alfalfa blooms sparsely and heavy rains occur it is best to cut the crop for

FIG. 23.—HARVESTING ALFALFA SEED IN WISCONSIN

Cutting the second crop of a thirty-acre field of Grimm alfalfa on the Cornfalfa Farms at Waukesha, Wisconsin, for seed. Seed growing, especially of the hardy varieties is proving profitable. Dry weather which cuts down yields of hay generally favors seed production.

hay. Fortunately where drought prevents a big crop of hay, seed production is generally at its best. The seed crop is handled and hulled exactly like red clover. Where hardy strains of alfalfa are grown the production and use of home-grown seed will tend to reduce winterkilling losses.

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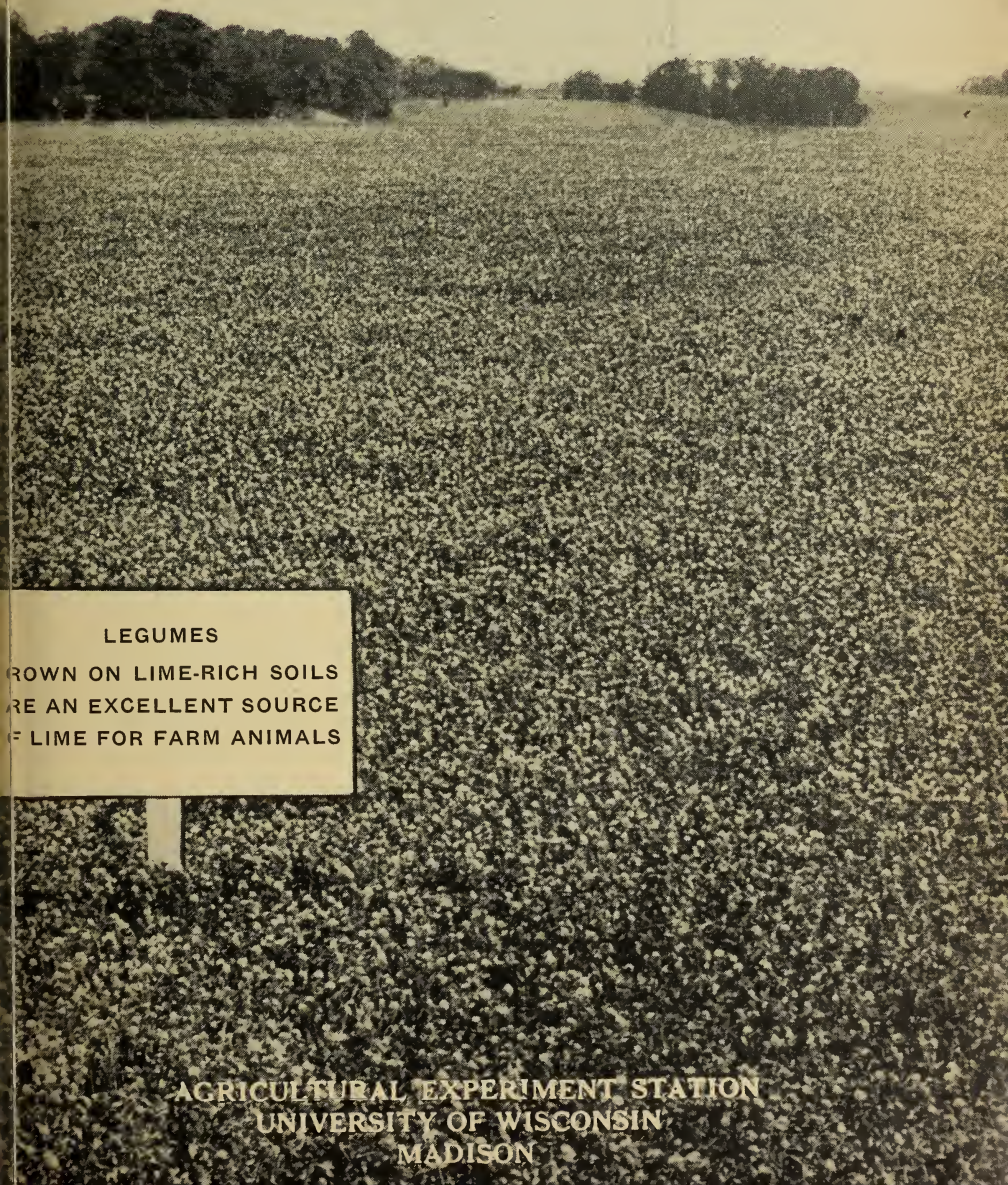
Minerals for Livestock



AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

LIVESTOCK NEED MINERALS

Supply all livestock with plenty of common salt. Page 3.

Guard against goiter and hairless pigs by using potassium or sodium iodide as an insurance where such trouble has been experienced. Pages 4-10.

When swine get no dairy by-products, tankage, or green pasture, feed a mineral supplement furnishing lime. Steamed bone meal, wood ashes, ground limestone, or rock phosphate may be used as the mineral supplement. One-half to two pounds of one of these mineral supplements may be mixed with each 100 pounds of ground grain or other concentrates, or the pigs may be allowed free access to a simple mineral mixture. Where dairy by-products are used, such as skimmed milk and buttermilk, or where tankage is available and the rest of the ration properly selected, there is probably no need for additional lime. If whey is used, a lime supply should be added. Pages 10-13.

Add a mineral supplement furnishing lime to the ration in feeding cows, sheep, and horses where the forage fed is grown on acid soils and is of a non-legume type. Steamed bone meal, wood ashes, limestone, or rock phosphate may be used at the rate of 3 to 4 pounds to 100 pounds of grain.

Even where the roughage consists of clover, alfalfa, or soybean hay the use of any of these minerals will do no harm and may perhaps be of benefit. If they are not completely absorbed by the animal, they enrich the manure, particularly when bone meal or rock phosphate are used, as these supply phosphorus. Pages 15-16.

Grains carry an abundant supply of phosphorus and wheat bran and middlings are especially rich in this element. Phosphorus added as sodium phosphate to the ration of a dairy cow during her dry period has been found to increase her milk flow the following lactation period. It would probably be unwise for farmers to take up phosphate feeding until there have been further experiments with diverse systems of feeding. Pages 17-19.

Most of the complex salt mixtures now on sale contain useless ingredients for livestock. Since the extra minerals needed for livestock can be purchased cheaper as simple ingredients and mixed by the farmer himself, it is uneconomical and unwise for him to purchase and use the commercial complex salt mixtures. Page 20.

Minerals for Livestock

E. B. Hart, H. Steenbock and F. B. Morrison

MOST FARMERS know that livestock require some extra mineral matter as a part of the daily ration. The kind of minerals to feed, however, and the amounts required by different classes of stock are questions upon which there is a wide difference of opinion. This difficulty is probably increased because of the fact that a number of individuals or companies in Wisconsin and neighboring states have various mineral mixtures for sale.

The importance of the problem and the need for an ample supply of mineral materials cannot be overemphasized, but use should be made only of those extra salts that are absolutely essential. Farmers should purchase only what they need and not buy complex mineral mixtures that may contain needless ingredients.

Livestock Need Salt

All farm livestock absolutely need a certain amount of common salt in the ration. This viewpoint is so common that it would be difficult to find many farmers who were not using common salt for their livestock. It is necessary to supply salt because the crops and feeds fed to livestock are very low in the element chlorine and it is this that common salt must furnish the body. Common salt makes hydrochloric acid in the stomach of the animal, and this is absolutely essential for proper digestion.

Experiments have shown that the dairy cow, for example, cannot get along indefinitely without an extra amount of common salt. Dr. S. M. Babcock carried on trials at the Wisconsin station twenty years ago and showed that if the cow was fed a ration that did not have added salt, finally her flow of milk would diminish and her general condition become impaired (see Figs. 1 and 2). The evidence is clear that farmers must feed common salt to all livestock unless some of the feeds they are purchasing already contain an extra supply of it.

Stock may be allowed free access to salt, they may be fed

FIG. 1—EFFECT OF LEAVING COMMON SALT OUT OF THE RATION

This cow appeared in this condition January 19, 1901, after having been deprived of common salt for 9 months. She had decreased in her milk flow markedly. Note the roughness of her hair coat.

salt at regular intervals, or it may be mixed with their feed. The most common plan with all stock except dairy cows and poultry is to allow them free access to it.

Dairy cows should receive a least 1 ounce of salt a head daily. A plan followed by many dairymen is to mix one-half pound to one pound of salt with each 100 pounds of concentrates, and then in addition to provide salt so the cows can have access to it and take what they wish. In the case of poultry, salt should form one-half to one per cent of their ration, depending on whether some of the feeds already carry added salt, as is often the case with meat scraps and tankage.

Iodine Prevents Goiter and "Hairlessness"

Especially heavy losses of new-born pigs, lambs, kids, calves, and foals, due to goiter or "hairlessness," have been experienced during recent years in certain sections of the northwestern states. Such trouble has been most prevalent in the region extending from the British Northwest through eastern Washington, Montana, the Dakotas, and into the region of the Great Lakes.

FIG. 2—THE SAME COW AS SHOWN IN FIG. 1, AFTER RECEIVING SALT FOR FIVE MONTHS

This photograph was taken on June 21, 1901, and shows the restoration to normal condition and the great improvement in appearance brought about by feeding common salt for 5 months.

The young so affected are usually born dead or weak, they are frequently nearly hairless, especially in the case of pigs, lambs, and kids, and they commonly have enlarged necks. It has recently been found that these conditions are due to the thyroid gland in the neck being diseased and enlarged, just as in the case of humans affected with the common type of goiter. This goitrous swelling presses on the wind pipe and interferes with breathing, often resulting in death from suffocation. Sometimes goiter develops after birth especially in calves.

The primary cause for hairlessness or goiter is not known; but recent experiments at this Station and elsewhere have shown that this condition can be prevented by administering iodine to the pregnant dams. It has been found that one of the functions of the thyroid gland is to make a certain iodine-containing compound which has important uses in the body. Near the sea coast humans suffer to a much less extent from goiter than in certain interior districts, and the same is true of stock. Apparently, this is due to the food plants in these interior districts being lower in iodine than

FIG. 3—A GROUP OF HAIRLESS PIGS

Hairless pigs are dead pigs. The losses from the production of hairless pigs in Wisconsin have been considerable, and such a loss can be avoided by the use of potassium iodide.

those grown near the sea coast. (The water of the ocean contains appreciable amounts of iodine.)

The forms of iodine used in treating animals to prevent goiter are potassium iodide and sodium iodide, whichever is the cheaper of these two forms of iodine.

Just how large a dosage of iodine is necessary to prevent goiter or hairlessness has not yet been definitely determined. However, experiments have shown that a daily dose of 2 grains

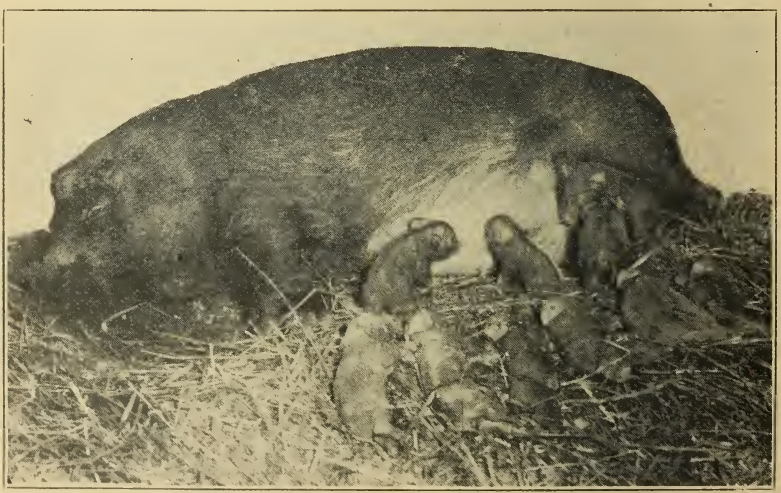


FIG. 4—A MIXED LITTER OF HAIRED AND HAIRLESS PIGS

A sow may produce a litter in which there are both haired and hairless pigs. The hairless ones are dead, while those with hair will show life and may be raised. This sow grew up on a ration of 30 parts of corn, 30 of oats, 30 of middlings, 8 of oil meal, and 1 of tankage. She was under strictly confined conditions, but appeared normal in every other respect except in reproduction.

of potassium or sodium iodide throughout the gestation period will prevent the trouble. This same daily dose is sufficient for sows, ewes, cows, or mares. Cows and mares will receive during their gestation period a total quantity of somewhat over one ounce of the compound, while ewes and sows will receive approximately one-half ounce, as their gestation periods are much shorter. It is entirely possible that a smaller daily dose would be sufficient to prevent the trouble, or else treatment during only the latter part of the gestation period. However, further experiments are necessary to decide the point.

It is rather difficult to mix the dry potassium or sodium iodide with the feed, as the quantity of the substance necessary is so small. Therefore, Dr. J. W. Kalkus of the Washington Experiment Station recommends that the potassium iodide be dissolved in water in the proportion of one ounce of the substance to a gallon of water. One tablespoonful of such a solution will contain approximately two grains of the compound and is, therefore, a daily dose. For horses or cows fed in the stable, it can be conveniently sprinkled on the feed

FIG. 5.—RAISING THE GILT SO AS TO HELP IN THE PREVENTION OF HAIRLESS PIGS

It is possible that hairless pig production is often the result of improper feeding of young sows, such as giving them too high protein feeds and too little roughage in the ration. This sow was reared on a ration of 75 parts of corn and 25 parts of alfalfa. While a sow receiving such a ration will grow at a slower rate than normal, yet the litters have always been haired and strong where sows have been reared on rations containing 15 to 25 per cent of roughage such as alfalfa.

each day. In the case of sows, the solution can be mixed with the feed, swill, or water, adding one tablespoonful for each animal in the pen.

If more convenient, about 320 grains (two-thirds ounce, troy weight) of the dry potassium or sodium iodide may be mixed thoroughly in each 1,000 pounds of the concentrate mixture fed the pregnant sows or other pregnant animals; for stock on pasture the dry potassium iodide may be mixed with the stock salt. In this case it will be necessary to estimate the amount

FIG. 6—A CORRECTION WITH POTASSIUM IODIDE

This sow had already developed goiter when the experiments with her were begun and had produced hairless pigs upon a ration of 33 parts of corn, 33 of oats, and 33 of alfalfa. When in the next gestation period 10 grams of potassium iodide per 100 pounds of the same feed were fed a normal haired litter of young was produced.

of salt the animals are consuming a head daily, and then mix sufficient of the potassium iodide with the salt so that they will get about two grains a day.

Calves affected with "big neck" or goiter may recover without medical treatment, but it is best to treat them for this trouble. Field experiments by Dr. F. B. Hadley of the Veterinary Science department show that a cure may be affected by

giving them two grains of potassium iodide a day for three or four weeks.

Overdoses of iodine or of potassium or sodium iodide have poisonous effects, first shown by watering of the eyes, slobbering at the mouth and running at the nose.

On one of the large stock farms in Wisconsin, tablets containing five grains of potassium iodide are placed every other day in the water buckets of the dairy herd test barn. These tablets are used for the sixty days preceding freshening. There has been no difficulty with goiter since this practice was begun, although the stock did suffer from goiter before potassium iodide was used.

FIG. 7—A NEW BORN LAMB SHOWING GOITER AND VERY THIN WOOL

The great success of Dr. David Marine in reducing goiter in school children at Akron, Ohio, by the systematic use of sodium iodide is a lesson to livestock men. By giving the children from the age of ten to seventeen, two grams of sodium iodide over a ten-day period, twice a year, he prevented goiter in practically all these children. The same quantity of potassium iodide could also be used. This public health measure in human nutrition should become a common measure of insurance against loss from goiter in the livestock industry.

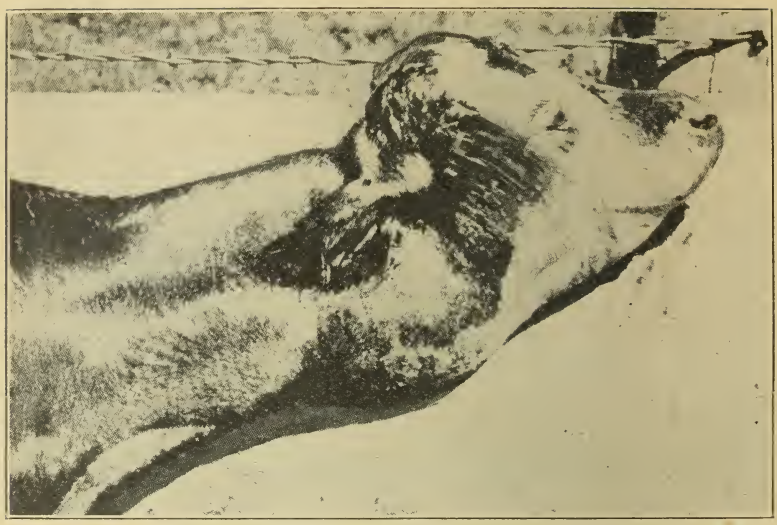


FIG. 8—A NEW BORN CALF SHOWING GOITER

This could have been prevented by feeding the mother potassium iodide. Calves in early life suffering from goiter can often be helped by painting the neck with tincture of iodine, or by giving potassium iodide.

In Wisconsin there is much less difficulty from goiter or hairlessness than in such districts as eastern Washington or Montana. Trouble is most apt to be experienced with hairlessness in new-born pigs after a severe winter with heavy snow fall. Apparently, the danger of this trouble is much less if sows, during the winter, are fed well-balanced rations, containing neither too much nor too little protein, and if they eat plenty of legume hay and are forced to take considerable exercise. Some Wisconsin farmers and breeders have never had trouble from hairlessness or goiter in their livestock, while others have experienced severe losses in certain years. Each farmer must decide for himself whether it seems advisable for him to go to the expense of administering iodine to pregnant sows, cows, etc. It is certainly advisable to use this treatment on farms where the conditions in question have occurred.

Should Lime Be Added to the Ration?

This question cannot be so definitely answered as in the case of common salt or of iodine. Whether extra lime should be added to the livestock ration depends upon what is fed.

Lime and phosphorus are widely used by all animals in building bone and by the dairy cow in producing milk. Compounding of rations from only seeds or seed by-products, will always result in a low-lime feed. For example, a mixture of corn meal, ground oats, wheat bran or middlings and oil meal would be too low in lime for the maximum growth of a pig. With such a ration a certain amount of lime would have to be added either in the form of steamed bone meal, wood ashes, ground lime stone, or floats (rock phosphate). These materials in the proportion of one-half to two pounds, to 100 pounds of grain mixture, depending on the supplement used, would provide ample lime.

When swine are fed shelled corn or ear corn, the mineral supplement can not be mixed with the feed, but should be fed separately in a suitable covered box or self-feeder. Such mineral supplements as ground limestone, wood ashes, ground rock phosphate, and bone meal, are not very palatable to pigs, and hence they may not eat enough of the supplement to have the desired effect. To increase the palatability of the mineral supplement, salt may be mixed with it, or else a small pro-

FIG. 9—RICKETS IN A GROWING PIG

This pig received a ration of white corn and skimmed milk and developed this condition after 7 weeks confinement to the ration. Rickets is not alone due to a low supply of lime or of phosphorus in the diet, because this ration carries a good supply of both these materials. In this case it was due to a lack of the vitamine that assists calcium assimilation. Dried alfalfa or dried clover would correct it. Cod liver oil would do the same thing.

portion of tankage or meat meal may be mixed with the mineral supplement.

For feeding to swine with ear corn or shelled corn and proper protein-rich supplements any one of the following mixtures may be used. There is at the present time no definite information as to just which one of these mineral mixtures will give the best results.

(1) Equal parts by weight of ground limestone and salt; or equal parts wood ashes and salt. These supply calcium but no appreciable amount of phosphorus.

(2) Equal parts of ground limestone, salt, and either bone meal or ground rock phosphate. This furnishes both calcium and phosphorus.

(3) Nine parts of either bone meal or ground rock phosphate and one part tankage for flavoring. These mixtures also furnish both calcium and phosphorus.

In supplementing with limestone (calcium carbonate) in animal feeding only high grade limestone should be used and not the magnesian limestone (calcium-magnesium carbonate).

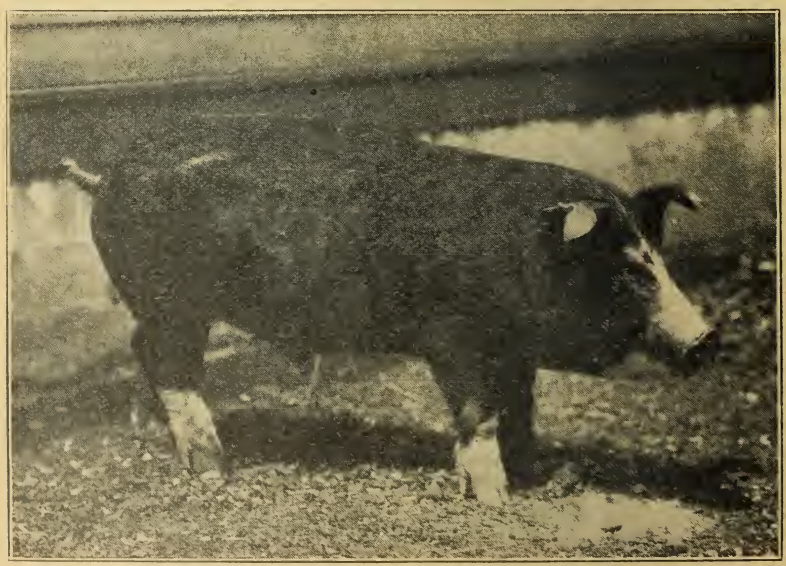


FIG. 10—THE SAME PIG SHOWN IN FIG. 9

Recovery from rickets was produced by the daily administration of 10 c.c. of cod liver oil. Twenty-five (25) per cent of alfalfa or possibly less in the ration would have accomplished the same thing. Green forage will also prevent it.

Such grain mixtures as mentioned above, however, do not produce normal growth; and the most successful hog raisers use either skimmed milk, whey, or tankage to supplement these grain mixtures. While soybeans, or certain other vegetable sources of protein may supplement corn successfully in hog raising, nevertheless it will always be necessary to add minerals, particularly lime, to rations made up exclusively of grain and seed by-products. Where plenty of skimmed milk or tankage is fed to balance the ration, there is probably no advantage from adding a mineral supplement to furnish additional lime, for both tankage and skimmed milk are rich in lime. However, growing pigs fed white corn and skimmed milk in dry lot, without any pasture, often develop rickets, a serious disease of the bones, which may cause paralysis and even death. This is not due to a lack of lime, but to the lack of a vitamine necessary for the assimilation of lime. If the mixture fed is yellow corn and skimmed milk, there is much less danger of rickets, because the yellow corn carries some of this needed vitamine.

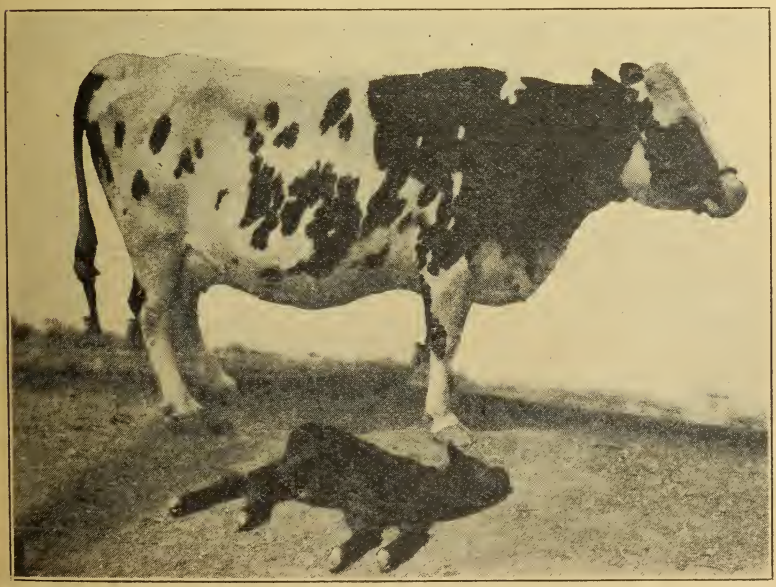


FIG. 11—RESULT OF FEEDING A RATION TOO LOW IN MINERALS

This cow received a ration of ground oats and oat straw during her entire gestation period. A premature and weak calf was produced. This result invariably follows from the continued use of roughage poor in mineral content, particularly lime.

The mere supply of calcium (lime) or phosphorus in the ration is not enough to prevent rickets, for bone formation requires not only an ample supply of lime and an ample supply of phosphorus, but also a vitamine that assists in assimilating calcium and phosphorus. Without the vitamine only a limited use is made of the calcium and phosphorus in the ration.

Supplementing a white-corn-skimmed-milk ration with ground alfalfa (5 to 10 per cent) will prevent rickets in swine. Tankage always carries a generous supply of bone meal and where it is used to supplement the grains, addition of extra amounts of lime materials is unnecessary. Where whey forms the supplement in winter feeding, it is wise to use an extra supply of lime. On the other hand, where grain mixtures and green forage are fed, such as clover, alfalfa, rape and pasture, there is no need whatever of an extra supply of lime.

FIG. 12—EFFECT OF ADDING MINERALS TO THE OAT PLANT RATION

This cow received a ration of 70 parts of ground oats, 7 parts of oat straw and 2 pounds of wood ashes per 100 pounds of grain. A fairly successful reproduction resulted, although the calf was not as strong as one produced on a natural roughage like clover or alfalfa hay.

Clover and Alfalfa Furnish Lime

Since such animals as cows, sheep, and horses get minerals, particularly lime, almost wholly from roughage, its mineral content is important. It has been demonstrated very clearly at this station that a cow receiving a dry roughage low in lime content and supplemented with grains, will usually abort her calf. This means not only loss of the calf, but also lowered milk production. The same thing has happened time and time again when wheat or oat straw was fed, as these are generally low in lime. On the other hand, where to such a ration a certain amount of lime salts was added, there was

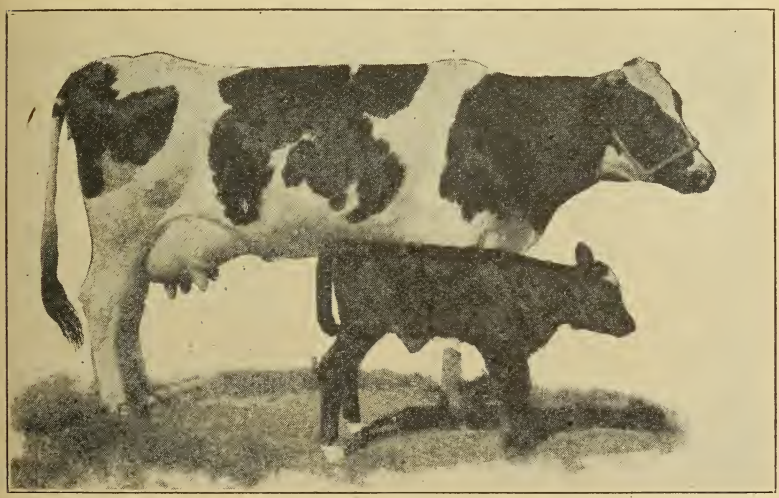


FIG. 13—EFFECT OF ALFALFA HAY ON REPRODUCTION

This cow received a ration consisting of 7 parts of whole oats, 4 parts of oat straw and 3 parts of alfalfa. She produced a strong eighty-four (84) pound calf. The introduction of alfalfa into the ration brought in more lime and more of certain vitamines.

marked improvement in the offspring, but they were not as thrifty as those produced when the roughage was a natural one rich in lime, such as clover or alfalfa hay. The stems and leaves of forage plants are variable in lime content, dependent upon the soil supply. If the soil is acid and low in lime, then plants, or parts of plants, like timothy hay, bluegrass, corn stover, or corn fodder, will have a relatively small amount of lime. Even red clover grown on an acid soil will be lower in lime than if grown upon a lime-rich soil; but nevertheless the

lime content of a legume plant, such as clover or alfalfa, will always be relatively high. Its minimum is high and if it cannot get the minimum, it ceases to grow.

Low Lime Roughages Cause Weak Calves

The relation of soil to plants is an important one. Corn stover grown on acid soils in this state has as low a lime content as .31 per cent. The same is true of blue grass or timothy hay. If these are the sole roughage of a cow during the entire gestation period, particularly if she is milking, weak offspring will surely result. Green pasture for a number of months in the year will help save the situation, however. This is important because animals will get along on a lower percentage of lime in their ration when they are given fresh, green feeds, like pasture, than when it is dry; and *they will also use or assimilate added calcium salts with greater efficiency on green forage* than on dried hays. This is because green materials contain more of the vitamine that assists in calcium assimilation than do the dried materials. The method of drying will also affect the amount of this vitamine left in the material. Drying grasses under caps preserves the vitamine much better than drying in the windrow with long exposure to sunlight.

The same thing is probably true of corn fodder and corn silage. Silage from field and sun-dried mature plants will not be as effective in making "available" the lime in the ration as will silage from green plants.

The fact that roughages low in lime may lead to premature and weak calves and that adding lime to the ration is helpful, has no doubt given rise to the idea that the Wisconsin Station has a cure for contagious abortion. This emphatically is not true. A cow may be getting the very best roughage grown, rich in lime, such as alfalfa or clover, and yet when she becomes infected with the germs of contagious abortion, she is quite likely to abort or to drop her calf prematurely.

On the other hand, the question may be raised as to how much of the weak offspring produced by our dairy stock is due to the feeding of forage low in lime and how much is due to infection. At present this question cannot be conclusively answered. However, it is certain that both factors play a role. There is no experimental evidence that contagious abortion or

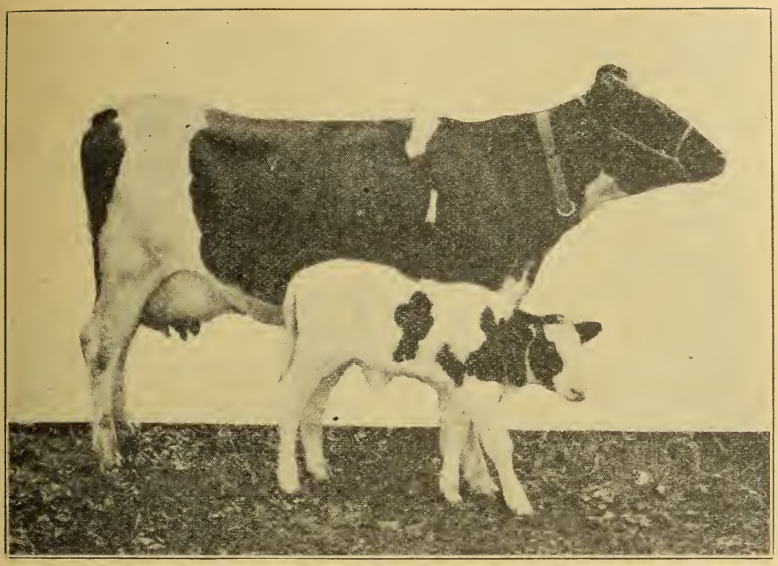


FIG. 14—A REPRODUCTION ON CLOVER HAY

This cow received a ration of 7 parts of ground oats and 7 parts of clover hay. She produced a strong, vigorous calf. The clover hay, like the alfalfa hay, carried more minerals in the ration, particularly lime.

sterility of cattle can be cured by the use of mineral mixtures of any kind but whether contagious abortion or sterility could not in part be eradicated if farmers used better roughages such as clover and alfalfa hay is an open question.

The best advice in the present state of knowledge is to grow and feed clover, alfalfa and soybean hay whenever it is at all possible. If you are forced to use poor hays or corn stover grown on acid soils and you have had losses in previous years from the premature birth of calves, add three to four pounds of limestone, steamed bone meal, wood ashes or floats (rock phosphate) to 100 pounds of grain for such livestock. This cannot possibly do any harm and may do a great deal of good. If you are a successful grower of clover, alfalfa, or soybean hay and have these for your dairy stock, then the need for adding lime carriers to the ration is less than with the poorer roughage. But even with legume hay available in winter feeding or when cows are not on pasture, the addition of lime carriers does no harm; and if they carry phosphorus, as do steamed bone meal or rock phosphate, the manure is en-

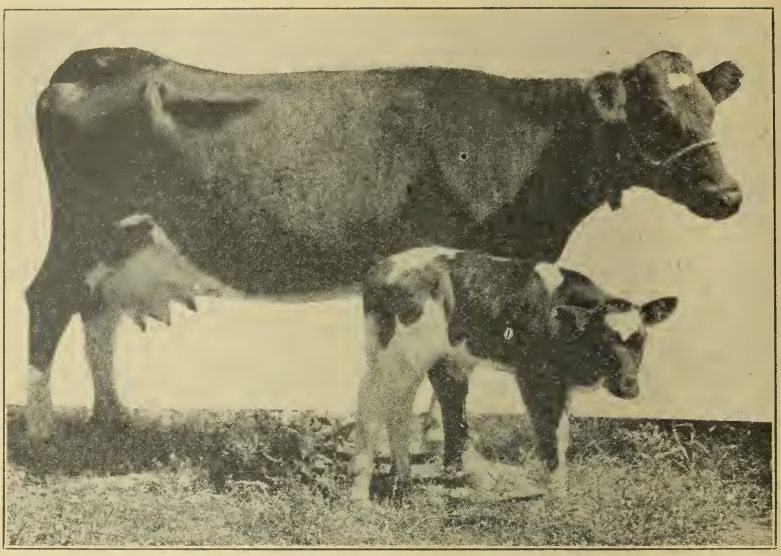


FIG. 15—WHAT MARSH HAY GROWN ON AN ALKALINE SOIL WILL DO

This cow received a ration of 7 parts of whole oats and 7 parts of marsh hay, which was grown on a soil rich in lime. This hay carried plenty of minerals, and the result was a strong, vigorous calf.

riched by their use. It is possible that the extended use of legumes plus lime carriers may produce unusually large-boned young with greater difficulties at birth. This should not cause worry, however, until experience shows it to be true.

TABLE I.—POUNDS OF LIME IN 1,000 POUNDS (AIR DRIED MATERIAL)

Wheat straw	2– 3	pounds
Corn stover	3– 6	"
Timothy hay	3– 5	"
Blue grass	4– 5	"
Clover hay	16–18	"
Soybean hay	17–18	"
Alfalfa hay	18–20	"

Hens Need Oyster Shells

In feeding chickens an extra source of lime other than the feed should always be given. Producing eggs is such a heavy draft upon the hen for lime that successful poultry raising demands the use of extra lime. Experiments conducted at the Wisconsin Experiment Station proved that the best form of lime to feed chickens is oyster shells, with clam shells a close

FIG. 16—LAYING HENS SHOULD RECEIVE EXTRA LIME

Hens on low lime rations do not lay soft shelled eggs, but cut off egg production and fail to lay to capacity. This station has found oyster shells or clam shells the best carriers of lime for laying hens. They are superior to bone meal or lime rock.

second. Why one source of lime should be superior to another (oyster shells over ground limestone) is not known, but it has been shown that oyster shells are a superior source of lime for laying hens.

Table II gives the egg production of groups of twelve pullets kept under the same conditions and on a ration low in lime, but having free access to their respective grit materials.

TABLE II.—EGG PRODUCTION

Grit material	First test	Second test	Third test
Oyster shell	1,606 eggs	557 eggs	976 eggs
Clam shell	.....	.....	916 "
Dry bone	1,033 "	507 "	.....
Lime rock	948 "	411 "	879 "
Quartz	577 "	221 "	325 "

Extra Phosphorus in the Ration

Grains are abundant sources of phosphorus, especially such by-products as wheat bran and wheat middlings. It is believed that for all classes of livestock receiving grains, especially wheat bran and middlings, the need for extra phosphorus would not warrant its purchase. Recent experiments, however, by Dr. E. B. Meigs of the United States Department of Agriculture, have shown that by giving cows a daily allowance of one-half pound of sodium phosphate, during their dry

period, greatly increased milk production in the following lactation period. These results are new and extremely interesting, but it is not advisable that Wisconsin dairymen take up the practice until further tests have been made under different systems of feeding. It is possible that feeding amply of wheat bran during the dry period of dairy cattle would fill the need quite as well as sodium phosphate, and for the present farmers should wait for more definite information.

Why Buy Commercial Mineral Mixtures?

Complex salt mixtures should not be purchased by farmers. For example, there is on the market a product widely advertised for dairy cows which consists of calcium phosphate, sodium chloride (common salt), potassium iodide, magnesium sulphate (Epsom salts), sodium sulphate (Glauber's salts), ferrous sulphate (Copperas), and sulphur. Why should sodium sulphate, sulphur, iron sulphate, or magnesium sulphate be added to a dairy cow's ration? If the cow is getting good clover or alfalfa hay in addition to her grains and silage, the only thing she needs in addition is some common salt, possibly some bone meal or wood ashes, and, if necessary, potassium or sodium iodide to prevent goiter. There is absolutely no need to spend money for any other minerals. "High test" cows are often fed charcoal. This, again, seems a perfectly needless expense, for there is no scientific information that justifies it.

A mineral mixture widely advertised for swine contains the same ingredients as the mineral dairy cow ration just mentioned, plus charcoal. If swine need some charcoal in winter feeding, then buy charcoal only and not all the other salts in such a mixture. But where hogs can go to a rack of clover or alfalfa hay, no charcoal is needed.

Another mineral mixture consisting of common salt, a low grade rock phosphate, and some calcium carbonate, or ground limestone is also sold. This is sold at too high a price for its actual cost or value.

There are other complex mineral mixtures on the market, but none of them have any merit whatever over the unmixed, simple ingredients that livestock need. There is no educational value in using an unknown mixture. To purchase intelligently the salts needed leads in many cases to a better under-

standing of the problems of nutrition and to a well grounded knowledge of agricultural science. There is nothing mysterious in these salt mixtures. The materials of which they are made can always be bought cheaper separately than in the complex mixtures now on sale. Such carriers of phosphorus and calcium that may be needed under special conditions can always be bought cheaper in steamed bone meal, wood ashes, ground limestone, or rock phosphate than in these mixtures.

Some of the commercial mineral mixtures on the market for swine may help to rid pigs of worms, but a specific and reliable worm remedy is preferable.

Combinations including santonin have been widely used with good results as worm remedies, but this drug is now high in price, and oil of chenopodium (American wormseed) is being commonly used in place of it. Castor oil should be given along with the oil of chenopodium as a physic. The dose for a 50-pound pig is 2cc. of oil of chenopodium thoroughly mixed with 15 cc. of castor oil. Proportionate amounts should be used for a large or a smaller pig. This worm remedy is best given as a drench after withholding feed for 18 to 24 hours. The dose should be repeated after a week or ten days.

The following santonin mixture is an excellent worm remedy, though rather expensive: Santonin, 2½ grains; calomel, 2½ grains; areca nut, 1 dram, and sodium bicarbonate, 1 dram. This is a dose for a 50-pound pig. Proportionately more or less should be used for pigs of other weights. This remedy may be given mixed with a thin slop, if the pigs are accustomed to slop. In this case be sure that each pig gets its share. It also may be given in a gelatin capsule.

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THE UNIVERSITY OF WISCONSIN
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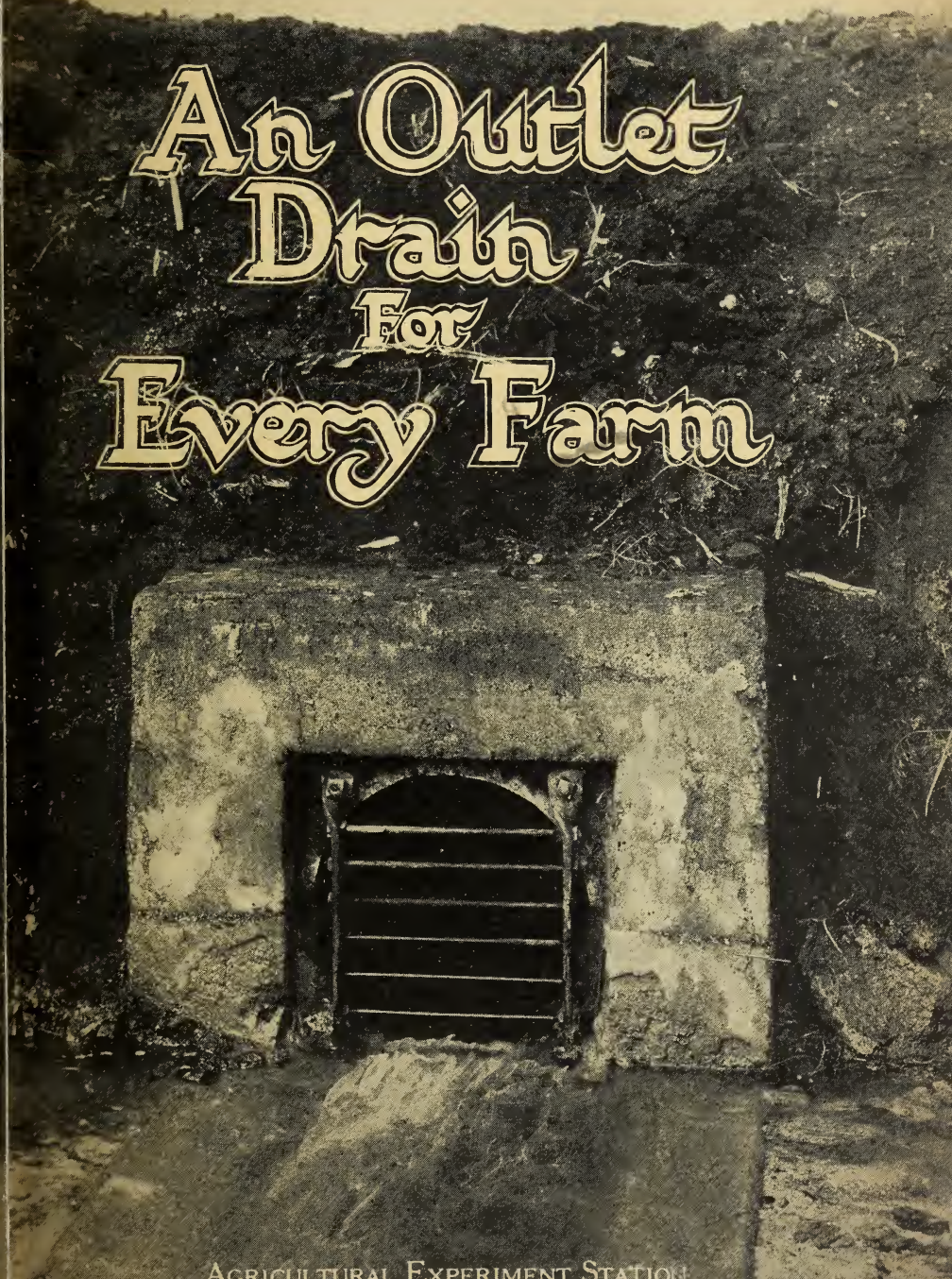
An Outlet Drain For Every Farm



AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
IN COOPERATION WITH
WISCONSIN STATE DEPARTMENT OF ENGINEERING
MADISON

DIGEST

State laws provide a means by which neighbors may cooperate in the construction and maintenance of an outlet drain serving a community. Without such outlets many farm drains would be valueless. Big tile are commonly used in place of open ditches. Pages 3-8

The better areas are due for improvement first. Among these are the low flat areas now cultivated, wild hay marshes adjacent to cultivated land, and timbered swamps where drainage is necessary to aid the construction of roads. A well financed colonization policy is essential to the success of the drainage of large marshes in sparsely settled localities. Pages 9-13

A majority of the land owners or the owners of half the land must petition the court to start a project. The court hears the merits or demerits of the proposition and may order the construction of the drains to proceed under the direction of a board and its engineer. Pages 13-18

The board assesses the cost on the basis of benefits. Outlet drains cost between $5 and $30 an acre. The average cost has been about $7. Distance from the outlet, the slope of the land and the kind of drains are the big factors in benefits. Damages are allowed where damage is done. Bonds may be sold to distribute the payment of drainage taxes over a period of 20 years if the land owners desire it. Pages 19-33

An index of the drainage laws, forms of petitions, reports, specifications and contract are given in the appendix. Pages 34-55

An Outlet Drain for Every Farm

E. R. Jones and O. R. Zeasman

WHY is there a marsh along the creek on so many Wisconsin farms? It is because the creeks are winding, sluggish, and full of stones or logs that retard the flow of water. The adjacent lands are too wet for profitable cultivation or good pasture. They will remain so until the owners get together and construct an outlet drain, perhaps several miles long.

Before deciding the extent and manner in which marsh lands are to be drained it is well to consider how desirable they are for farming or road-making. It is better to postpone the organization of a drainage project for a few years than to install it prematurely.

Successful drainage demands that the outlet drains be deep enough; that the lateral drains be sufficiently frequent to furnish adequate under drainage; and that farmers know how to use such lands correctly.

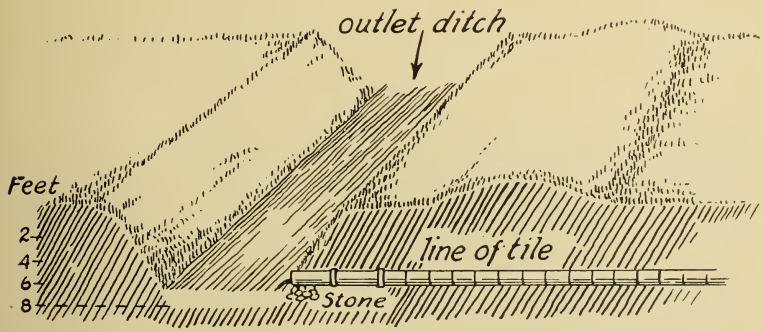


FIG. 1.—GIVE THE TILE AN OUTLET

Two lengths of glazed sewer pipe with cemented joints supported by stone make an inexpensive, serviceable outlet where the normal water level in the ditch is nearly up to the tile.

There are certain laudable enterprises that necessitate keeping some wet areas. The owners of such lands, however, should not be required to keep their lands wet for the benefit of others without just return for the actual losses sustained.

Intensive forestry and intelligent drainage harmonize, for often our best forests are on well-drained land. The mischief is done where haphazard, partial drainage of peat lands surrounded by natural forests has threatened both marsh and forest with destruction by fire. With adequate drainage and good farming the surface of the marshes is kept free from inflammable rubbish, and the deep rooted trees in the wood lots thrive better.

Generally it is best not to drain marshes until the advance of farming from the surrounding upland demands it. To this rule there are exceptions, providing a well financed policy of colonization or utilization is made a part of the drainage plan. One is found in northern Wisconsin where a marsh requiring no land clearing can be drained, broken and seeded to tame grass for a smaller cost per acre than the surrounding cut-over land can be cleared and stumped. Another is found in parts of central Wisconsin, where the drained peat lands can be made more productive of cultivated crops than the sandy uplands surrounding them.

Draining Through Your Neighbor's Land. Abundant fall affords an outlet without crossing the line fence. Less fall requires entering the land of a lower neighbor for the neces-

FIG. 2.—AN OUTLET DITCH

This was dug with a floating dredge. It is 20 feet wide at the top and 7 feet deep. Its sides are somewhat steeper than is advisable.

sary outlet. A mutual agreement with the neighbor, each agreeing to pay his share of the cost of construction, is the simplest form of procedure. If the neighbor is unwilling to cooperate in this way, he may be forced to cooperate under, (1) The Farm Drainage Law (Chapter 446, Laws of 1919), or (2) The Drainage District Law (Chapter 557, Laws of 1919), provided the public health or general welfare will be promoted thereby. In either case three disinterested men fix the tax that each owner is to pay for the construction of the outlet drain, or the damages to which he is entitled. When such awards are approved by the county judge or the circuit court, they are enforcible.

Your Share Is Fair. The benefits must exceed the cost. Otherwise drainage would not be profitable and were better left undone. The benefits are usually more than twice the cost. For this reason, a land owner errs when he expects his neighbor, the state or the nation to contribute money toward the construction of an outlet drain for his farm, except when such contributors also receive tangible, financial benefits from the proposed drain. It must be established that the public health or general welfare will be promoted by the drains.

Miles Men Have Made. Wisconsin has about 2,000 miles of open ditches and large tile constructed under state laws, chiefly during the last twenty years, giving an outlet to about 800,000 acres of land and consisting of about 200 independent projects. The largest of these projects consists of 75,000 acres. Another large project has 60,000 acres and 120 miles of ditch. The smallest project on record consists of only 40 acres with an outlet ditch only 1 rod long. But that rod extends across the line fence where a neighbor had constructed a dam to hold back the water on the upper owner. In that case, upon petition of the upper owner, a profile was made and recorded, showing the grade of the water course for 80 rods below the offending dam, to prevent the lower owner from constructing another such dam in any portion of the water course thus recorded.

Many small projects have been partially or wholly installed under state laws, but the records kept by town clerks under the Town Ditch Law (repealed in 1919) are imperfect, and some of the ditches have but little value. During the three years following the enactment of the Laws of 1919, a total of

FIG. 3.—BIG TILE WIN FAVOR

These tile are 48 inches in diameter. They are more expensive but better than open ditches. Even a 12-inch tile with a surface run is better in many places than a large open ditch.

103 projects have taken steps toward organization. Of these, 17 were dropped or postponed upon the recommendation of the College of Agriculture and the State Chief Engineer. The other 86 are proceeding toward completion or are completed. They contain 217,110 acres and 660 miles of open ditch or large tile costing $2,326,832.

Big Tile Win Favor. Sluggish, winding streams have been deepened, straightened and placed on forty-lines where possible. Open ditches are made by floating dredges or walking or dry-land dredges.*

For short ditches, the overhead expense of building a large dredge is high, and some of the smaller dredges on the market are desirable. Dynamite also can be used with advantage in short ditches. The smallest outlet ditch advisable is 6 feet deep, 3 feet wide at the bottom and 15 feet wide at the top. Wherever a smaller ditch than this is sufficient, a big tile aided by a dry, shallow, rounded surface-run at its side is cheaper and better. Big tile are growing in favor as land becomes more valuable. They require less for maintenance. They waste no land; leave no uncultivated strip for weeds; can cross highways without expensive bridges; and cost but little more than open ditches. When a dredge crosses a road, the bridge usually has to be reconstructed. This difficulty decreases where the highway officials have been far-sighted enough to put in the concrete foundations of their bridges deep enough that they reach down below the grade line of the

*Advantages of each are given in Bulletin 300, United States Department of Agriculture.

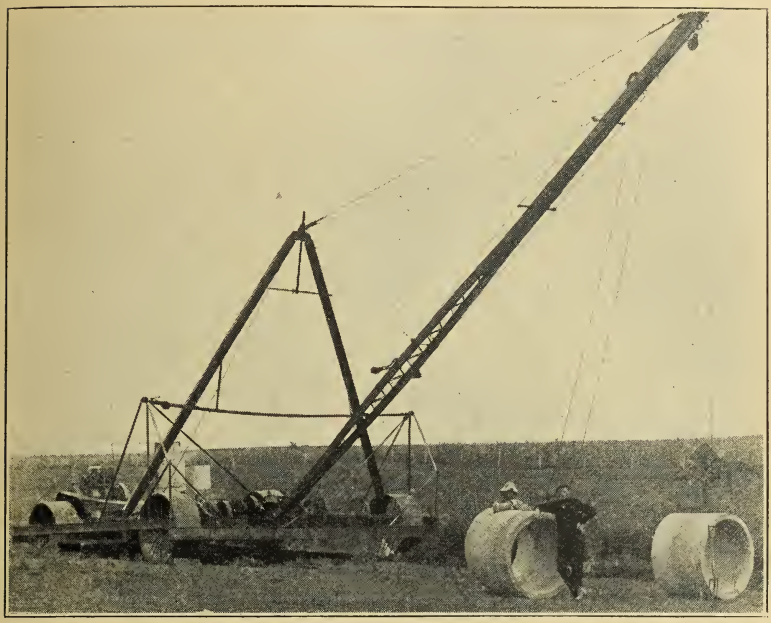


FIG. 4.—TILE LAID BY MACHINE

This machine digs the trench with a dipper suspended from the boom. The heavy tile are then swung into place by a block and tackle from the same boom. The smaller tile are laid by hand and the smaller trenches are dug either by hand or with tiling machines.

proposed ditch. Any farmer owning marsh land above a highway where a new bridge is proposed does well to confer with the highway officials when they are designing a new bridge in an effort to get the bridge foundations deep enough so that they will not have to be underpinned when the ditch is constructed.

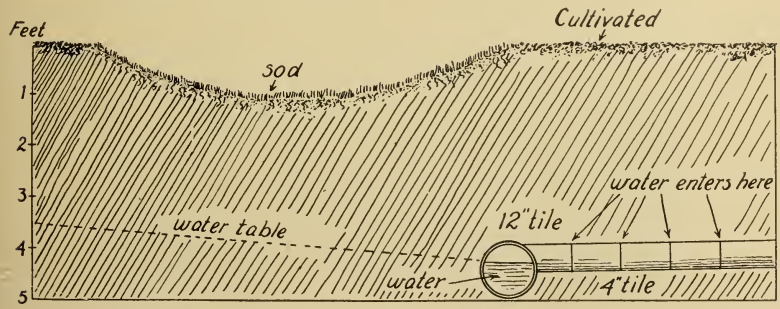


FIG. 5.—TILE AND SURFACE RUN

The tile carries the seepage and water from the tile laterals. The surface run carries water during a flood and is dry enough to raise hay the rest of the time.

LOW LANDS LYING WASTE

Peat and Muck. Peat is partly decomposed vegetable matter that has accumulated in the marshes. Before drainage it was virtually pickled. After drainage the acids leach out and air and bacteria come in. It then decomposes into muck, becoming more solid and darker in color. A technical definition of muck requires that it contain 50 per cent or more mineral matter, but this is not the muck of the farmer's vocabulary. In this bulletin muck means a soil that was once peat, but which has decomposed through drainage until it has lost its tough, fibered structure.

Marshes and Swamps. There are at least six types of wet lands. (1) Marshes are wet most of the year. They usually have a peat or muck soil and support wild grasses. (2) Swamps are the same as marshes except that they support trees or brush. (3) Overflowed lands are wet only when the adjacent stream overflows. (4) Pot holes are depressions that have no surface drainage. (5) Seeped areas are those kept wet by seepage from higher lands. (6) Tight soils are those that are kept waterlogged by the slow rate of percolation. The last two classes frequently have so much fall that the necessary tile drainage systems do not require the extension of the outlet into the land of a neighbor.

FIG. 6.—A CAPSTAN DITCH

Three feet deep but too shallow to serve as an outlet for tile.

Where to Drain First. Low, flat, cultivated fields on which labor is expended annually but wasted by the drowning of cultivated crops demand attention first, particularly the narrow wet strips in well drained fields.

Areas where drainage can be made profitable, but where it may well await the convenience of a majority of the land owners, are:

(1) Wild hay marshes, particularly the smaller ones that have well-developed upland adjacent to them. Corn or timothy and alsike is more profitable than marsh hay.

(2) Timbered swamps across which a road is to be constructed. It may be cheaper for the county to dredge a ditch 8 feet deep for the entire length of the swamp than to haul

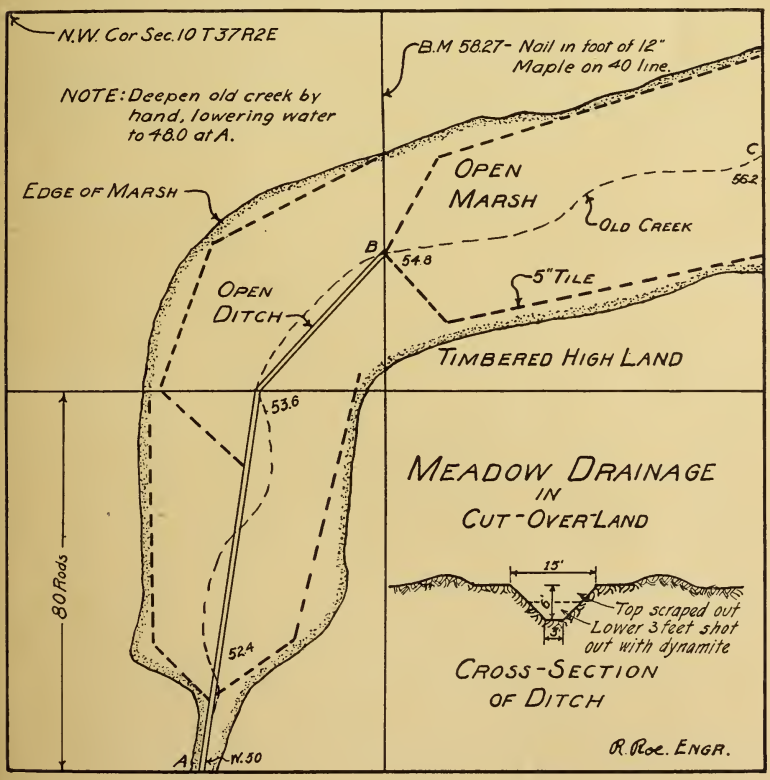


FIG. 7.—HAY MEADOW DRAINAGE

Dredge or dynamite a ditch 6 feet deep down through the center and cut off the seepage at the edges with a line of 5-inch tile. It does not pay to bother with little ditches only three feet deep. The hay crop is too uncertain with shallow drainage.

in enough earth to build up the road to a height of 4 feet. Let the county pay for part of the dredging and the farmers pay for the rest and both will gain thereby.

(3) Areas kept wet by small mill-dams in well-developed agricultural communities. Where the Railroad Commission of Wisconsin finds that the agricultural value of the land damaged is greater than the commercial value of the water power or pond, the farmers, through a drainage district duly organized, are permitted to purchase and remove the dam at a stipulated or fixed price paid to the owners of the water power.

(4) Wild hay meadows in undeveloped cut-over areas that can be converted into timothy and alsike meadows at less cost than that of clearing the surrounding upland.

Finishing the Job. The outlet drain is but a starter. The land must be broken for a seed bed. Supplementary drains are necessary in most cases after the outlet drain is dug. This means laying enough lines of tile to complete the drainage, except in sandy sub-soils. In such soils, ditches that reach 4 feet into the underlying sand and are one-half mile or a mile apart, with a line of 5-inch tile at the edge of the sandy upland or larger islands to cut off the seepage, give satisfactory drainage. *More failures in marsh farming are due to the neglect in putting in the supplementary drains than to any other cause.*

Care prevents damaging fires in peat soils. Burning-off all the surface rubbish as soon as it is dry in the spring and before the peat is dry enough to burn, lessens or eliminates the fire hazard. The older trees on a timbered swamp may occasionally die with drainage. Cutting and marketing them the first year after drainage is advisable. The younger trees develop deeper roots and thrive better thereafter.

A peat marsh with a clay sub-soil is usually better than one with a sandy sub-soil, but the latter is more easily drained. While open ditches in sand must have a slope of 1½ to 1, and the joints of tile must be protected from the sand by a layer of peat or a wrapping of heavy paper, the drains may be farther apart. Even with only two inches of peat on the surface, and certainly with six inches of peat, the sandy marshes have more organic matter than the sandy uplands and to that extent are more valuable, except as they are more subject to frost. Drainage does remove some water from sandy soils

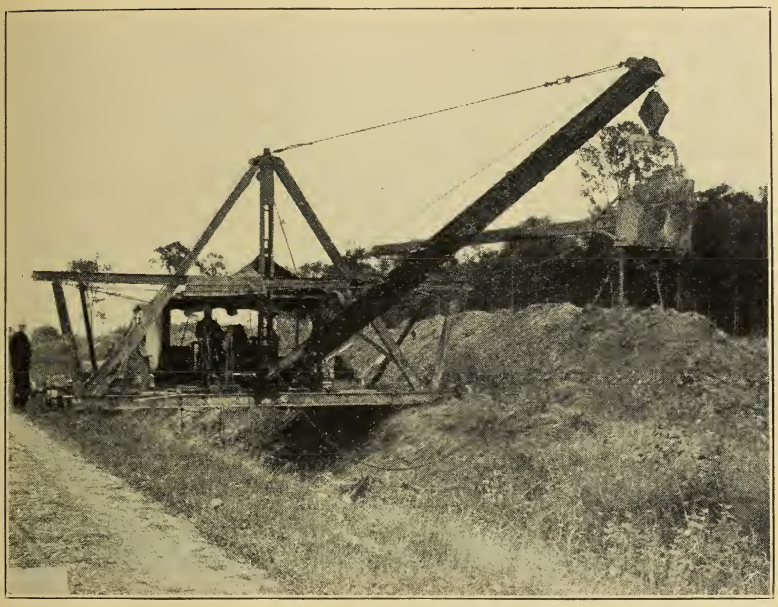


FIG. 8.—A DRY LAND DREDGE

This dredge straddles the ditch and digs up stream best. It has a walking device or track for moving along the ditch or from one job to another without dismantling.

that might be used later by plants, but to compensate for this loss, the plant roots go deeper into the soil after drainage and for that reason resist drouth better. The ideal plan is to have deep drainage during the spring, followed by sub-irrigation during the summer, where it can be accomplished by bulkheads in the ditches. To do this there must be plenty of water running in the ditches in dry weather.

Some Marshes Should Wait. Chief among the less desirable wet areas, for agricultural purposes at present are:

(1) Marshes that cannot be drained without impairing the beauty or usefulness of lakes.

(2) Timbered swamps interspersed with little or no open marsh, particularly in Northern Wisconsin.

(3) Large marshes in sparsely settled localities, unless a well financed development or colonization policy is assured. This may mean carrying the development to the raising of the first crop before it is sub-divided into farms for settlers.

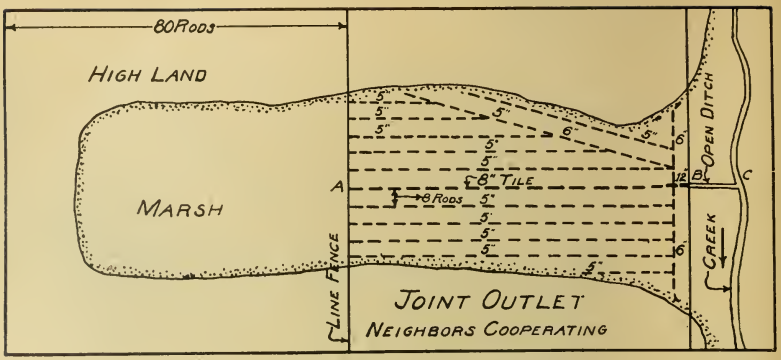


FIG 9.—NEIGHBORS CO-OPERATE

The 8-inch tile from A almost to B is the equivalent of a 5-inch tile to the lower owner. The lower owner contributes the cost of a 5-inch tile and the upper owner pays the remainder of the cost of the 8-inch tile. Each pays half for the open ditch from B to C, where the land is too low to be tiled. The upper owner connects on the 8-inch tile at A. The lower owner pays the extra cost of a short line of 12-inch tile.

THE LAWS THAT GOVERN

Try Mutual Agreement First. Two or more land owners may agree as to how much each is to pay toward the drain and then install it themselves. If this is not possible, the next step is to proceed according to the special statutes.

The Two Laws Are Similar. Simple projects are handled best under the Farm Drainage Law administered by the County Court. They are called farm "drainages." The complicated projects involving navigable waters or unusually large areas are best handled under the Drainage District Law administered by the Circuit Court. There is no maximum or minimum limit to the size or cost of projects under either law. Out of 103 projects started in the first three years of the operation of these laws, 9 are drainage districts and 94 are farm "drainages." The chief difference is that each drainage district has three special commissioners appointed to take charge of it, while a permanent board of three men in each county known as the "farm drainage board" takes charge of all farm "drainages" begun in the county. If a project lies in two counties, the board of the county having the larger acreage as described in the petition has jurisdiction. A drainage district may be placed in the circuit court of any county in which any part of the lands lie.

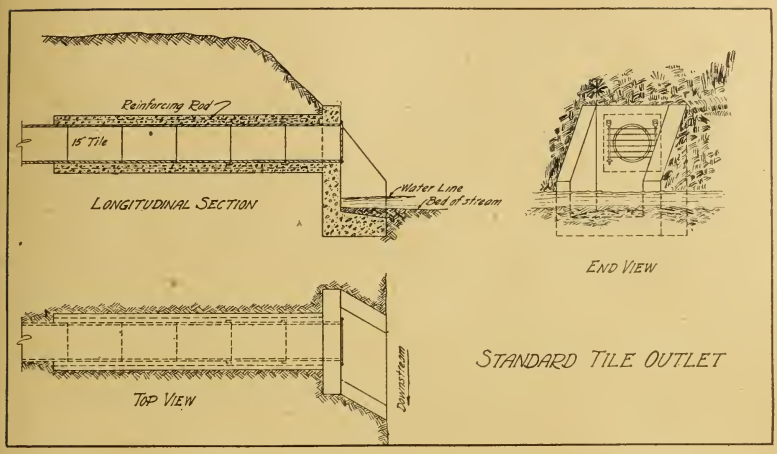


FIG. 10.—PROTECT THE OUTLET

Reinforced concrete 4 inches thick to give tensile strength and prevent leakage under the face. The wing walls deflect the water down stream. The foundation is deep to resist frost action.

Owners Petition Court. A majority of the land owners holding one-third of the land in a project or the owner or owners of more than half the land must sign the petition. Suggestions for such petitions appear in the Appendix (page 38). It is best to let a reliable, experienced drainage attorney responsible to a representative committee of land owners take charge of the petition and present it to the court. An attorney who has handled other projects successfully can save the land owners considerable time and money. The land owners can aid the attorney by preparing a sketch of the forties included in the project and the approximate location of the proposed drains. This sketch satisfies the requirements of the petition. If time permits, an extension worker of the College of Agriculture will go over the area with the owners to aid them in deciding what forties to include. The boundaries of the project may be changed later, but it is essential that a tentative boundary be established so that the court can determine the sufficiency of the signatures.

The State Chief Engineer. The laws require that all drainage districts and all farm "drainages" containing more than 200 acres (5 forties whether all marsh or not) within its boundaries shall be under the direction of the state chief engineer. By virtue of the statute he requires:

(1) That all project engineers be approved by the state chief engineer. Such approval has now been extended to 36 engineers who are eligible to work on any project in Wisconsin so long as their work is up to standard.

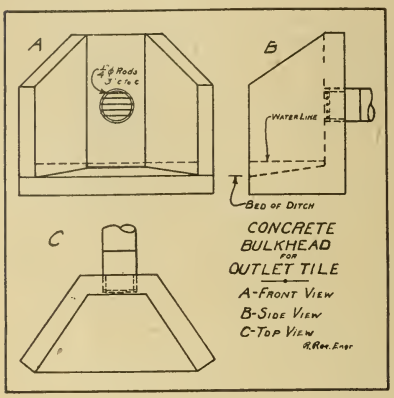


FIG. 11.—GOOD FACE BUT POOR BODY

Unless the tile are imbedded in reinforced concrete for 8 or 10 feet back from the outfall, the water will escape through the cracks between the tile and undermine the foundation of the face.

(2) That the board engage one of these engineers to make a preliminary survey of the project and send to the state drainage engineer four blue prints of a map showing preliminary plans and topography. It is well for the engineer to correspond with the state drainage engineer while making the preliminary survey and plans.

(3) That the College of Agriculture prepare a report on the quality of the soil and the crops to which it is adapted.

(4) That the board include this soil and crop report, together with a feasibility report by the state drainage engineer, with its preliminary report to the court.

(5) That the final report of the board containing final plans and assessments be submitted to him for recommendations or

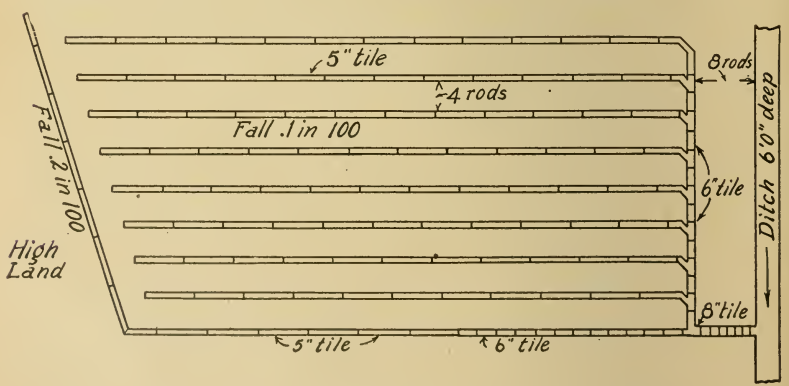


FIG. 12.—AVOIDING TROUBLESOME OUTLETS

This is accomplished by having several laterals discharge into a single drain. A line of tile is located at the edge of the high land to cut off the seepage. Farmers put in systems like this after the outlet drains are constructed by the drainage board.

approval before it is filed with the court, preferably while it is in preparation.

The College of Agriculture cooperates with the state chief engineer by extending to him the services of its drainage specialist as state drainage engineer.

The Preliminary Survey. When a drainage board directs an approved engineer to proceed with the preliminary survey, it relies upon him to collect all of the important data to determine feasibility at a cost not exceeding 2 per cent of the cost of construction of the proposed drains. Detailed, expensive surveying is inadvisable at this stage because the project may prove to be not feasible. In that event the court dismisses it and assesses the cost of the survey and hearing against the petitioners on the acreage basis. It is not fair to ask the petitioners to be responsible for any more surveying than is actually necessary to determine the feasibility of the project. Later, after the project is assured, is the time for the accurate survey.

Figure 19 is a satisfactory preliminary map and Figure 20 a preliminary profile. Well established bench marks and other reference points recorded on the blue prints are of use in the final survey and there is no loss in duplication.

The board may order the engineer to survey topography outside the boundary of the project petitioned for, but only where this additional land should be included or otherwise affects the project. In the event of dismissal, this additional survey also must be paid for by the petitioners. If the court organizes the project, the cost of the preliminary survey is made a part of the cost of construction and is paid by a tax against all of the land and corporations benefited.

No drains are staked out during the preliminary survey. Some engineers have wasted time staking out drains, measuring the angles, and have neglected to take important readings well selected over the marsh to determine approximately the slope of the land toward the proposed drain.

A specimen of a preliminary report of the board based on the preliminary survey appears in the Appendix (page 43). The edge of the wet land is shown only approximately. The board ascertains in a general way the benefits and the cost of the proposed work. A letter from the project engineer to the state drainage engineer, describing the sub-soil, topography

FIG. 13.—CLEAN OLD DITCHES

Where the spoil banks have been reduced by partial leveling, a machine like this can clean out a ditch at a reasonable cost. This is a good practice from five to ten years after the original ditches are dug and the slopes are seeded.

and size of catchment, size and condition of bridges and character of the existing stream, is of value to supplement the data shown on the preliminary map.

The Engineer's Responsibility. A good engineer demands authority to make the plans and specifications and accepts responsibility for their execution. He scorns the idea of "passing the buck" to the board or to the state drainage engineer. If the board, or the state drainage engineer, insists upon plans which the project engineer cannot support with enthusiasm, confidence and good faith, he should resign, instead of betraying his board by pretending to execute plans that he would rather see fail than succeed because he did not favor them. With the responsibility of inspecting the work of the contractor, the board gives the engineer authority to enforce specifications to his own satisfaction.

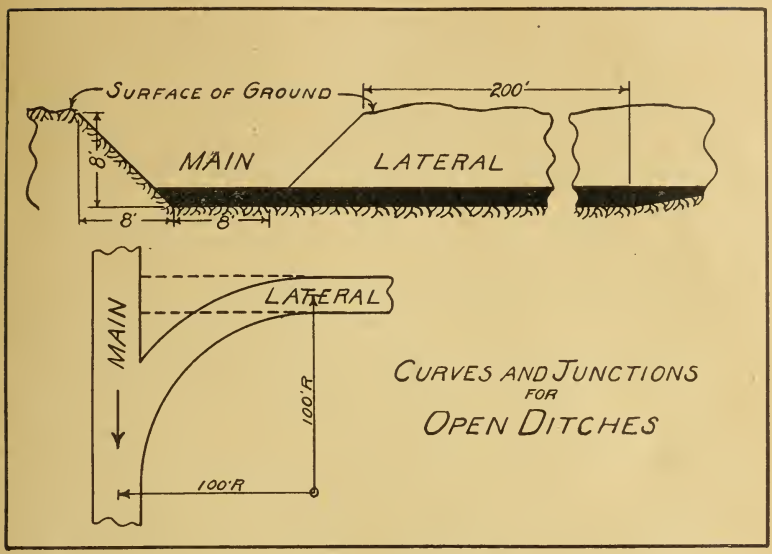


FIG. 14.—CURVES AND GRADES FOR LATERALS

To prevent erosion at the junction make the first 200 feet of the lateral as deep as the main. Have a gentle curve down stream. The larger ditches or swifter streams may require a 200 foot radius.

The Final Report. If the hearing on the preliminary report proves the project advisable, the board is instructed by the court to prepare its final report. This includes the final location and design of the drains and the assessment of benefits and damages to each parcel.

The final report is based on the final survey. The engineer stakes out the drains with a station marked by a stake every 100 feet on the lines of the drains. He takes elevations on the ground at the foot of these stakes, but for safety does not set the reference hubs until the board has let the contracts for construction and the contractor is ready to start the work. If these hubs are set too long in advance of construction, they may heave with freezing or be disturbed by tramping, or be burned or moved to facilitate the cutting of marsh hay.

The final map (Figure 21) shows the location of the drains accurately and the finale profile shows their depths. The elevations of the ground at the critical places on each parcel and an accurate location of the edge of the wet land are necessary to the board in determining benefits.

The engineer is the man to make the plans and be responsible for them. If he is competent, his plans are usually ac-

ceptable to the board. The assessment roll is prepared by the board "with the aid of the engineer" and an equitable assessment is based in great part upon the findings of the engineer and the soil examination. The purpose of asking the board to send a tentative draft of its final report and plans to the state chief engineer is to permit him to make his recommendations and suggestions before the report is put in final form or filed with the court.

The Board May Borrow Money. When the court refers a petition to the board it may authorize the board in writing to borrow a limited sum in the name of the petitioners to make the preliminary survey and pay preliminary expenses. After the hearing on the preliminary report, when the court authorizes the final survey, it orders the board to borrow another limited sum to meet the necessary expenses. All of these expenditures are later added to and become a part of the cost of construction. After the final report is confirmed, the drainage taxes for the entire cost of construction are due, unless the court permits the debt to be paid in installments by the sale of bonds or notes based on the assessments. The latter is the common practice although any land owner may, up to the time of the selling of such bonds, pay the court his entire drainage tax. Bonds are then sold only to the extent of the unpaid taxes. Installments to pay assessments in farm drainages shall not exceed fifteen in number, the first one falling due one year after the assessment is confirmed, and one falling due each year thereafter. In drainage districts the first of the fifteen annual installments must fall due not more than five years after confirmation. The statute must be carefully complied with in every respect, or the attorney for the bond buyers will not approve the bonds for purchase.

Hearings Required. Land owners are given several opportunities to remonstrate and be heard by the court. Each law provides three distinct hearings. First on the petition, then on the preliminary report, and last on the final report. Ten days or more of notice is given to each land owner of each hearing so that he may examine the petition or report to be heard and prepare his remonstrance if he feels that the project should not go forward or that he is being wronged. The hearing on the petition for a farm "drainage" is informal but must be in strict accordance with the statute. The board, after

notice of time and place of meeting, meets the land owners at some convenient place near the proposed drain to hear their complaints or comments. The rest of the hearings are held in the court room before the county court. Town boards and railroad officials are also notified. Highways and railroads must open their right-of-ways to permit the construction of drains, but damages must be allowed them to the extent of the expense incurred.

LANDS ASSESSED FOR BENEFITS

Computing the Benefits. Benefits to the land are measured by the increase in value due to the proposed drainage. It is necessary first to fix a value "before drainage" and a value "after drainage" and to subtract the former from the latter to ascertain the benefits.

Value Before Drainage. The value of agricultural land before drainage is determined largely by:

1. Proximity of roads and markets.
2. The brush or rubbish on the surface which must be removed before the land can be plowed.
3. The quality of the soil.
4. Difficulty of drainage as determined by topography, subsoil and natural or artificial obstructions.

Lands with high elevations but kept wet by seepage have less need of a dredge or deepened outlet, and therefore their value before drainage is usually greater than that of lands no wetter but having a lower and more unfortunate elevation. Even though the higher lands are just as wet and produce no more crops than the lower lands, they are worth more because of their fortunate topography. They may be worth $40 an acre, while the lower lands are worth only $10 an acre. If both are worth $70 an acre after the outlet drains are established by law and constructed, the higher wet lands are benefited only $70 minus $40, or $30 an acre, while the lower lands are benefited $70 minus $10, or $60 an acre. Wet lands 10 feet higher than the surface at the proposed ditch 80 rods away have a natural outlet as good as the low lands will have after a ditch 8 feet deep is dredged, and are benefited only to the extent of the legal rights afforded by the organization.

Wet lands lying above a railroad or a rock layer or a bed of quicksand have those obstacles in the way of their drainage, and their value before drainage will ordinarily be correspondingly low for that reason.

Value After Drainage. The value after drainage has the value before drainage for a background, but with the additional factor of the quality of drainage to be affected by the proposed drains. Near the outlet the water may not be lowered very much due to lack of fall, and the value after drainage will be but little in excess of the value before drainage. Not until a point is reached where tile can be laid 4 feet deep with a descending gredient of .1 in 100 feet to the top of the water in the outlet drain at reasonable stage, do benefits reach a maximum. Lands that are given an outlet anything short of this will not attain normal value after the proposed outlet is constructed and will not receive maximum benefits.

To serve as an adequate outlet for level land 80 rods away from an outlet drain the top of the water in the outlet must be normally about 5½ feet below the top of the ground. This means that the bottom of a 12-inch tile in such cases would be 6 feet deep. An open ditch, if used, would have to be dredged about 2 feet deeper than that to provide for the deterioration common to open ditches with little fall. Outlet drains shallower than these specifications do not render maximum benefit.

High Lands Benefited. "Islands" of high land surrounded by marsh have a low value before drainage because of their inaccessibility, and the benefits to them may be as great as those to the surrounding marsh. High lands cut into irregular fields by the encroachment of arms of the marsh are benefited because they can be made into convenient rectangular fields after drainage. High lands now in rectangular fields but included in the project for convenience of description are usually benefited only by the reflection of benefits from the adjacent lands. Actual measurement of the high, intermediate, and low areas on each parcel by the engineer is essential as a part of his final survey.

Laterals Increase Benefits. A parcel of land a mile away from an outlet may be benefited, but not so much as if a lateral is put in from the main drain to a low part or corner of the distant parcel. Two methods are used. Either assess low

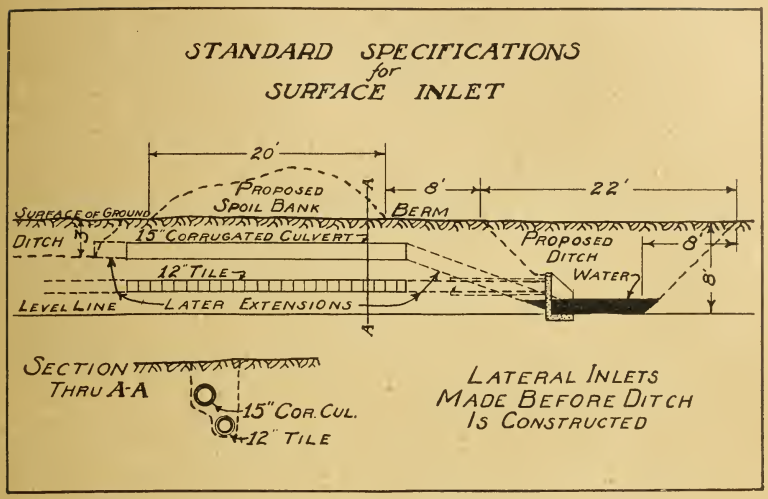


FIG. 15.—MAKE INLETS FIRST

Dig a trench under the proposed spoil bank. Lay tile of required size about 5 feet deep and a 15-inch corrugated culvert about 2 feet above the tile, using a pump to keep trench dry during construction if necessary. After the ditch is constructed, extend each to the ditch.

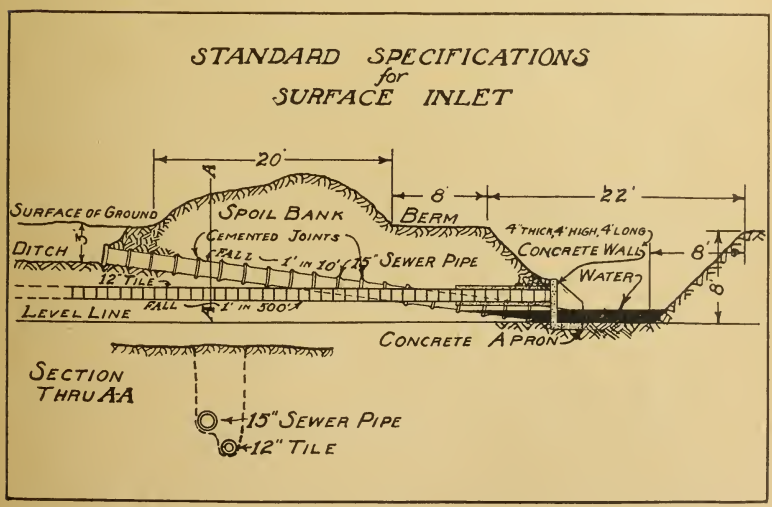


FIG. 16.—CULVERT UNDER SPOIL BANK

It injures a ditch to admit surface water directly. Continuous spoil banks leveled to permit cultivation protect the ditch slopes from erosion. Use a culvert to admit the water from the abandoned bends of the old creek bed.

benefits on the distant parcel and postpone the construction of the lateral, or put in the lateral and assess all parcels benefited by it high enough so that each will have to pay its just share toward the lateral, in addition to the contribution toward the main.

Direct Drainage Extra Benefit. An outlet drain not only provides an outlet for smaller drains, but renders some direct drainage itself. If an open ditch or a big tile extends through the interior of a forty it does as much or more direct draining as a line of 5-inch tile would do if laid at the same depth. This is in excess of the service an outlet drain would render if its end merely touched one corner of the forty like the SE¼ NW¼ section 3 in Fig. 21.

It is reasonable on good land needing drainage to assume that the benefits of the direct drainage afforded by a main drain is about $4 per linear rod of drain where the drain is wholly within a parcel of land, or $2 a rod where the drain is on the boundary of the parcel. Where the drain is an open ditch this benefit is decreased by the inconveniences of the open ditch and the land occupied by it. There is not such compensating damage resulting from a tile.

Where creameries, cheese factories, canning factories, or dwelling houses are on land within the district the benefits from furnishing sewerage outlet for those factories or dwellings are assessable against land because in most cases buildings are legally land. If they are legally not land the benefits to them can be assessed only if they are the property of a corporation.

Benefits to Roads. Both railways and highways need drainage. The other alternative is to build the road bed up two feet or more above high water. Assuming that before drainage the water frequently reaches the top of the road between Sections 2 and 3, the proposed drains offer a means both of reducing the peak of the flood during high water and drying up the base at all times. To get maximum benefits it is necessary to lay a line of 5-inch tile on the west side of the road, but the outlet for this is provided. It is safe to assume that the benefits of the drains as shown are the equivalent of hauling in enough earth to build up the road 2 feet. If the roadway is 27 feet wide this would require 5,280 cubic yards in the one-half mile of road. At 50 cents a cubic yard the saving

due to drainage alone would be $2,640, a pro rata part of which should be paid by the town or county responsible for building the road. Where the proposed drainage will reduce the cost of maintaining or repairing a road, it is a benefit.

TABLE I.—OPEN DITCHES—COST, CONTENTS AND CAPACITY.

Bottom width	Depth	Top width	Acres drained	Cubic yards per mile	Cost per mile
2	6	15	4,300	10,550	$1,600
4	6	16	5,000	11,750	1,750
6	6	18	6,500	14,000	2,100
4	7	18	8,500	15,250	2,300
6	7	20	11,000	17,750	2,600
8	7	22	13,000	20,600	3,100
4	8	20	13,000	18,750	2,800
6	8	22	16,000	22,000	3,300
8	8	24	18,000	25,000	3,750
10	8	26	22,000	28,000	4,200
6	9	24	22,000	26,500	4,000
8	9	26	26,000	30,000	4,500
10	9	28	30,000	33,500	5,000
12	9	30	33,000	37,000	5,500

Side slopes of 1 to 1 are assumed. In sand or unstable muck, slopes of 1½ to 1 are necessary. The capacity of the ditch is based on a fall of 3 feet per mile with the crest of the flood 2 feet below the banks and with 1 foot of sediment in the bottom of the ditch. The acreage is based on the removal of ¼ inch from the area in 24 hours. The cost is based on 15 cents a cubic yard. The cost will be more than this if less than 3 miles in length.

Damages. Damages within the project consist of mutilation of land necessitating bridges and irregular fields, occupation of land, removal of stock watering places, or killing of timber. Damages below the project may result because of the water carried by the proposed drain. In any and all cases the land damaged must be compensated in some way. Damage may be allowed to cover the cost of a bridge. Land occupied is paid for by the acre at the rate of its value before drainage. This damage is eliminated where big tile are used or where the old ditch occupies as much land as the one proposed. The old ditch can usually be filled up at a small cost after the new ditch is dug. For $50 a satisfactory watering place can be excavated usually at the side of the ditch and fenced from it. Or, if the new ditch cuts off the water from a pasture, the damage can be measured by the cost of well, windmill, and tank. The killing of timber by lowering the water table is usually limited to 100 feet or less each side of the ditch, and where the timber is cut and marketed with advantage the first winter after drainage the damage from this source is negligible.

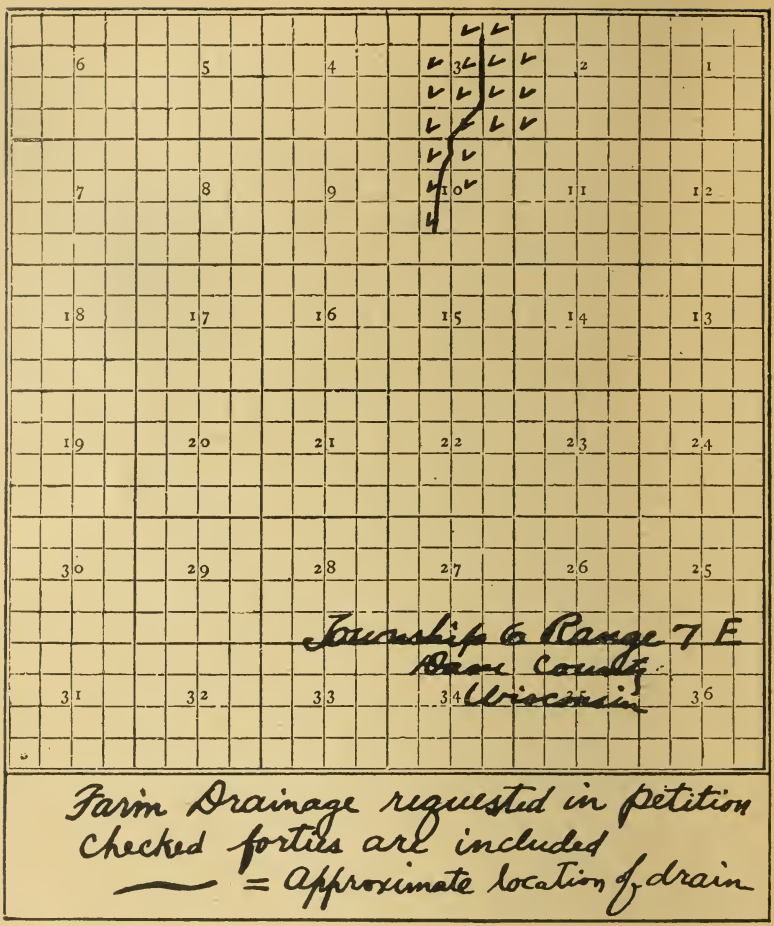


FIG. 17.—SKETCH FOR PETITION

Check the forties that are to be included. Show approximately the location of the proposed drains. Boundaries and locations may be changed after the survey is made.

It is seldom that damage is done below the project by the increased discharge of a good outlet ditch and its supplemental laterals after the first year. These drains lower the water table on the area drained and keep the soil dry enough to absorb more of the rainfall than it did before drainage. This equalizes the runoff on the land below and reduces the floods. Immediately after the construction of the outlet ditch and before the laterals are installed to complete the drainage, the runoff may be greater because the soil to be drained has not

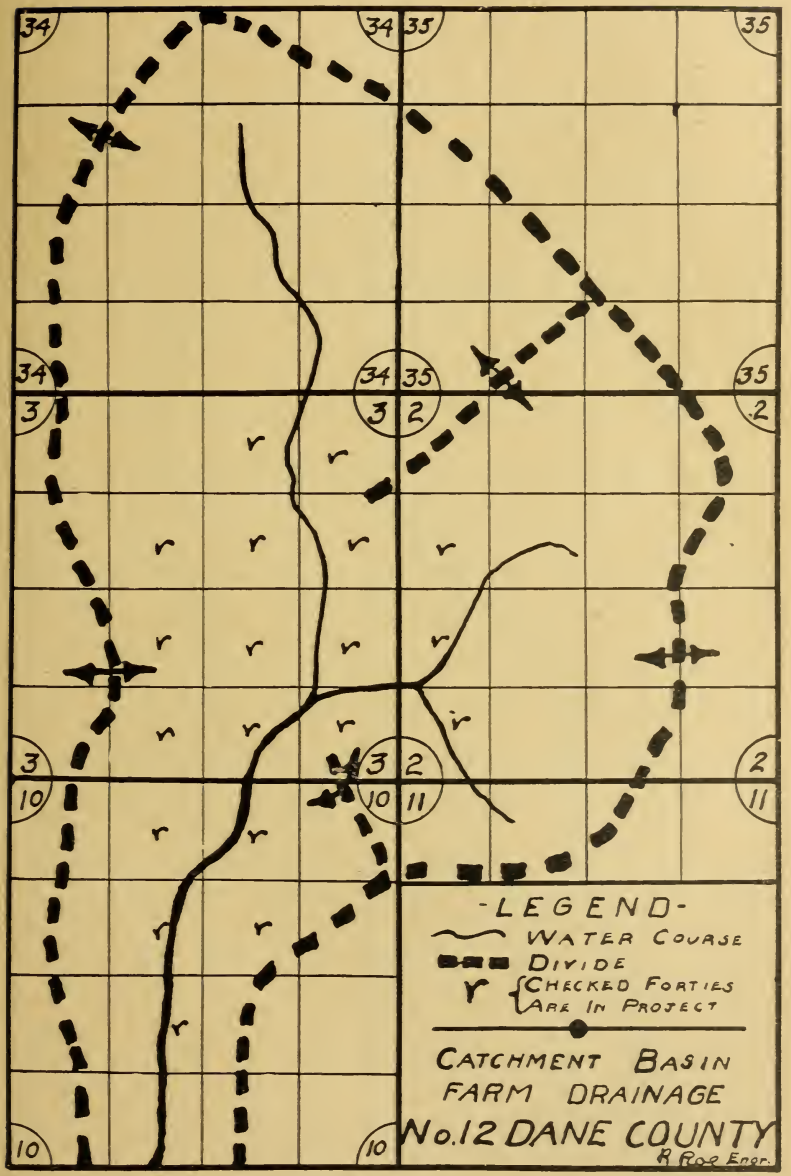


FIG. 18.—THE CATCHMENT BASIN

The engineer examines the size and character of the catchment basin as a basis for the design of the drains.

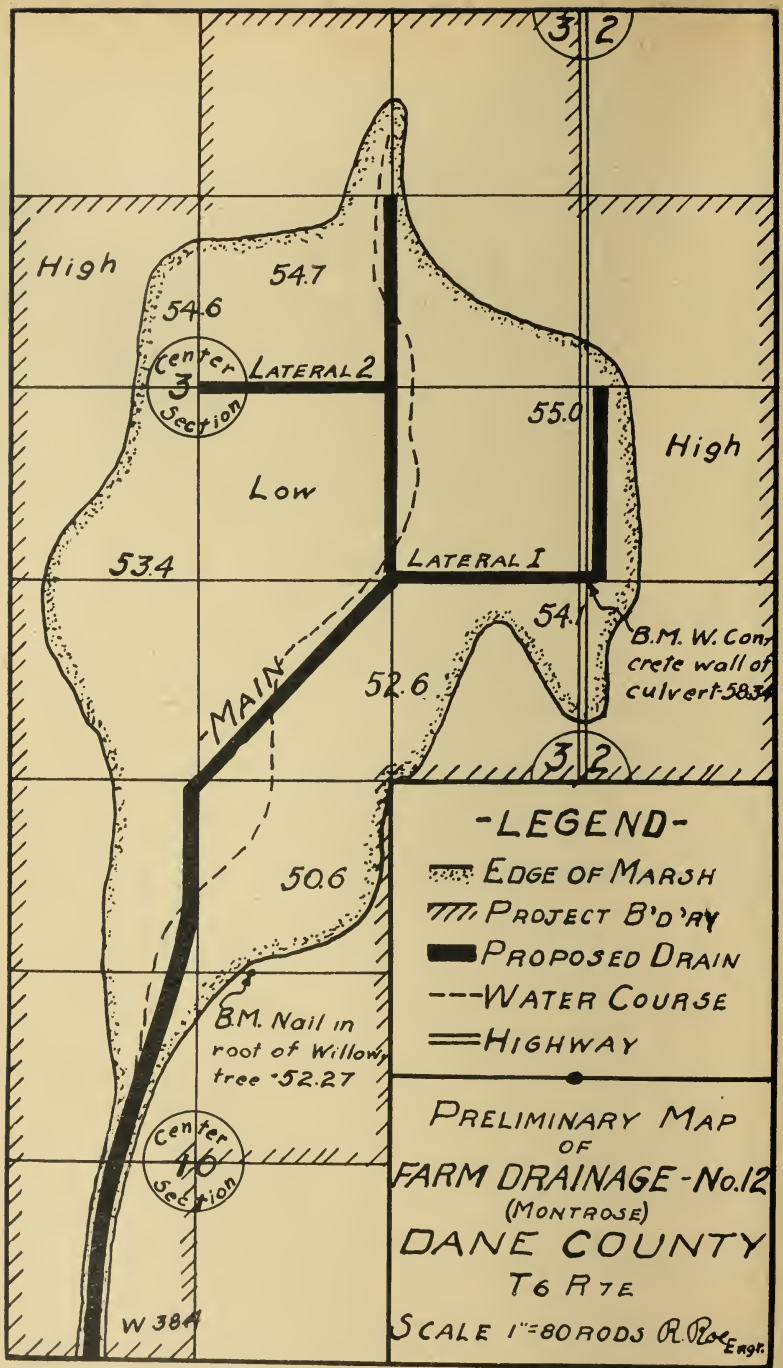


FIG. 19.—THE PRELIMINARY MAP

The purpose of this map is to show only the features that are to determine feasibility. A scale of 1-inch to 80 rods or 1-inch to 1,200 feet is desirable.

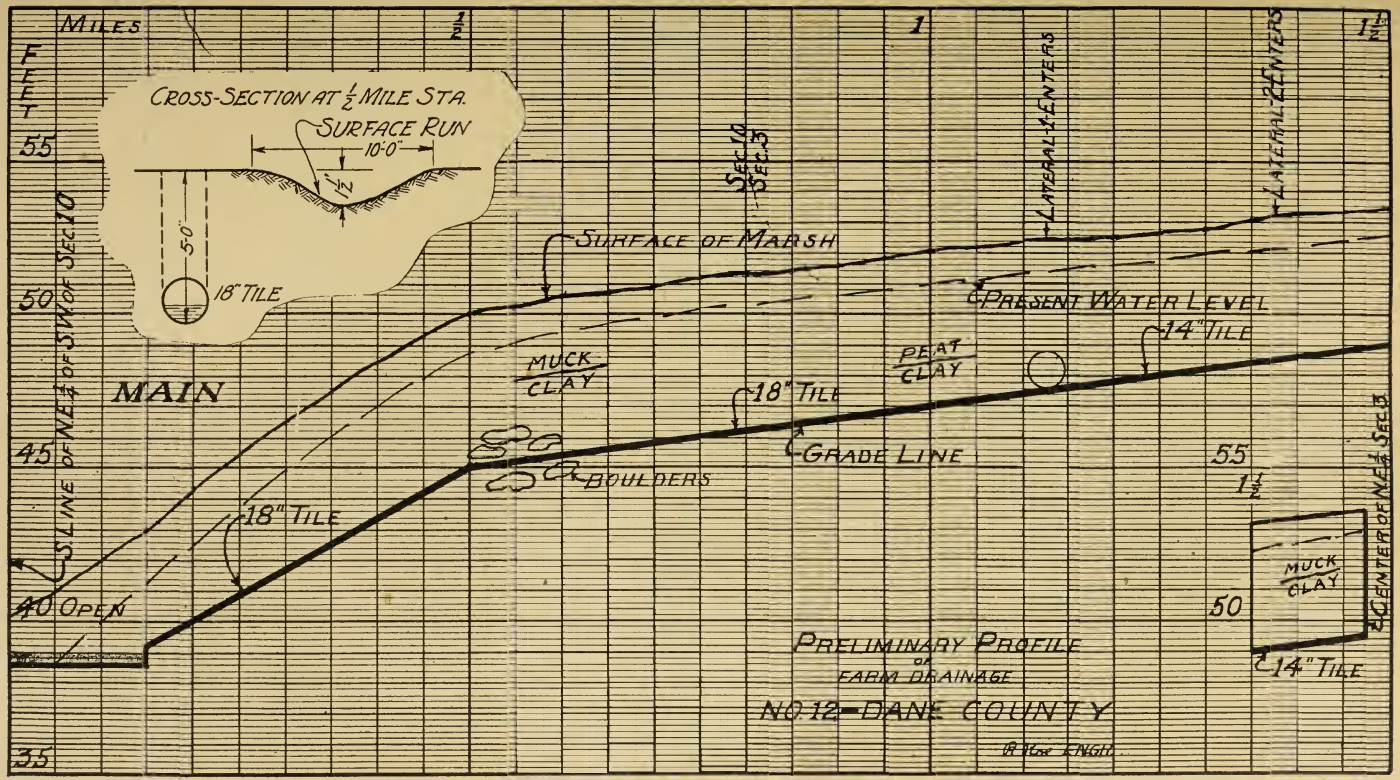
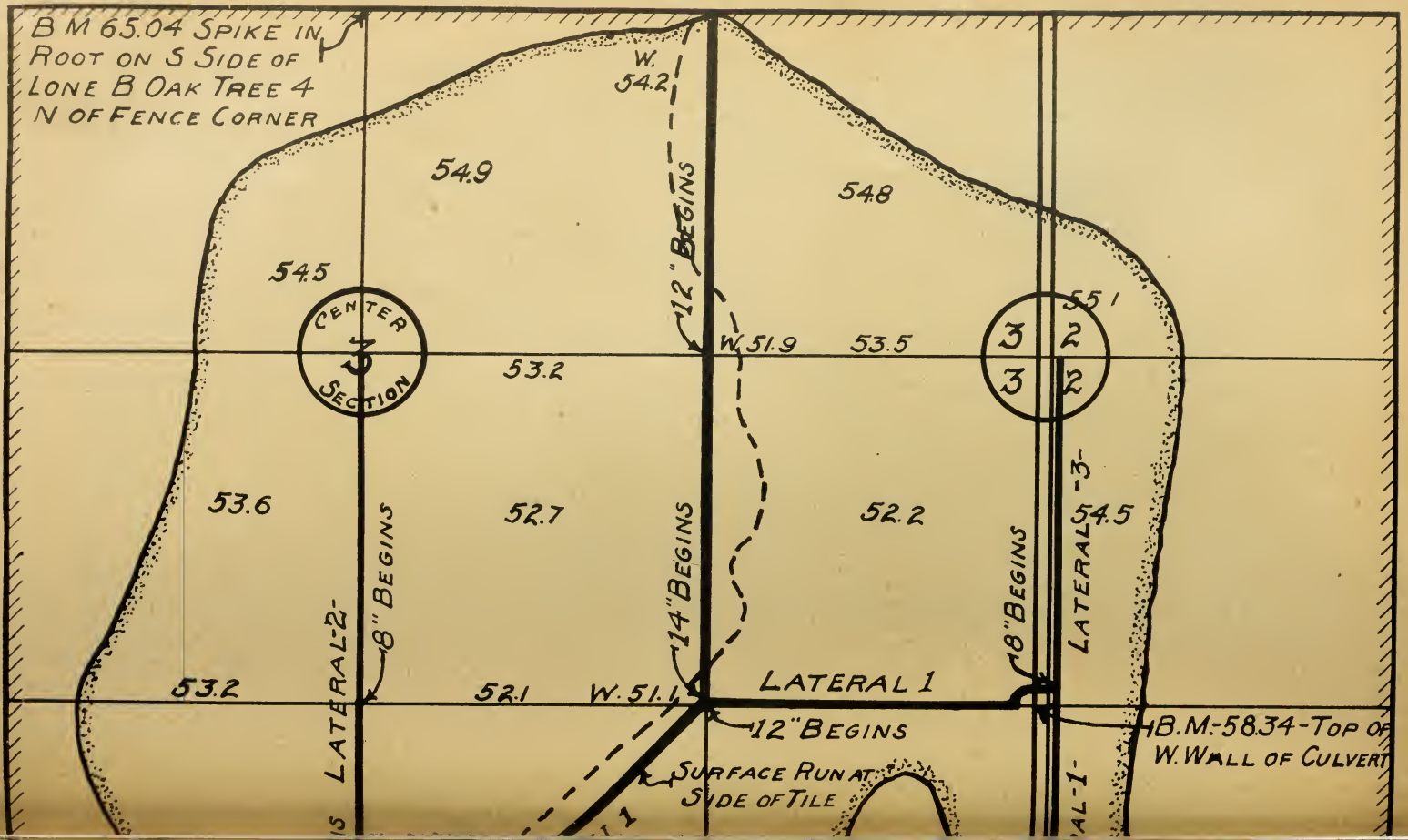


FIG. 20.—A PRELIMINARY PROFILE

Not accurate in all details, but convenient and does not cost much.


B M 65.04 SPIKE IN ROOT ON S SIDE OF LONE B OAK TREE 4 N OF FENCE CORNER
W. 54.2
54.9
54.8
12" BEGINS
54.5
CENTER SECTION
W. 51.9
53.5
55.1
53.2
53.6
52.7
52.2
54.5
8" BEGINS
14" BEGINS
18" BEGINS
LATERAL-2-
LATERAL-3-
53.2
52.1
W. 51.1
LATERAL 1
12" BEGINS
B.M.-58.34-TOP OF W. WALL OF CULVERT
SURFACE RUN AT SIDE OF TILE

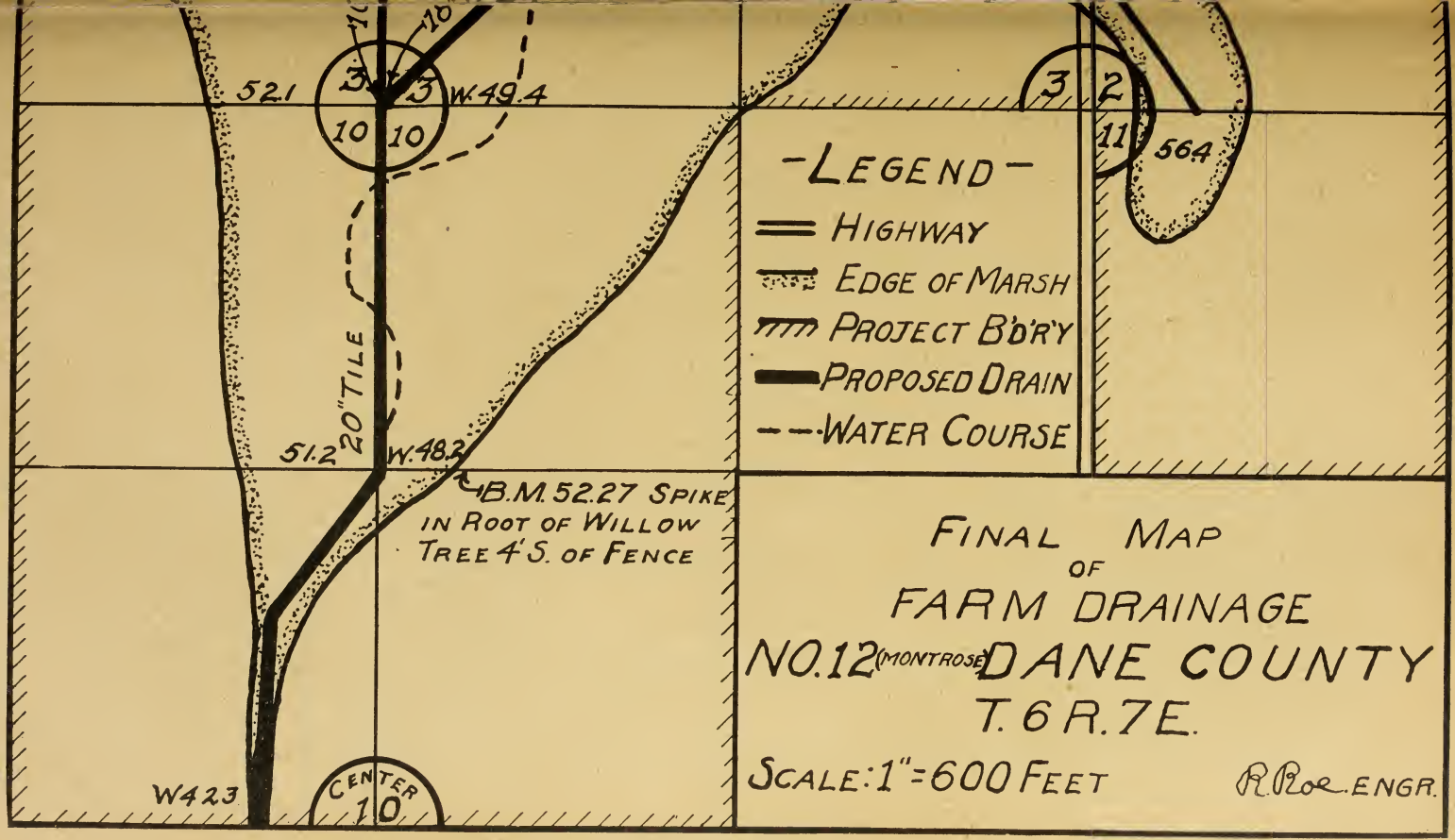


FIG. 21.—THE FINAL MAP

Accurate and complete scale 1-inch equals 600 feet. Used by the board and the engineer in making the assessments against each parcel of land.

yet been given its absorbing capacity. A capstan ditch or other ditch which is not deep enough to drain thoroughly may cause considerable damage below its outlet. Likewise, any drain that reaches outside its natural basin brings in more than the natural amount of water, which may or may not do damage. Before such damages can be established it must be shown that poorer crop of hay or corn or similar crops are grown below the outlet than were raised under similar conditions before drainage.

TABLE II.—COST OF TILE AND TILING.

Diameter, inches	Pounds per foot	Acres drained	Cost in dollars per 100 feet								
			Tile	Labor—Depth in feet							
				3	4	5	6	7	8	9	10
4	6		4	4	5	7	10				
5	8		5	4	5	7	10	14			
6	11	21	6	5	6	8	11	15	20		
7	14	32	9	6	7	9	12	16	21	27	
8	18	44	12	7	8	10	13	17	22	28	35
10	25	75	20	8	9	11	14	18	23	29	38
12	33	130	28	9	10	12	17	21	26	32	42
14	43	190	36	10	11	14	18	23	29	36	47
15	50	225	39		12	16	21	27	34	42	53
16	58	270	42		13	18	24	31	39	48	60
18	70	360	60		15	21	28	36	45	55	68
20	83	475	75		18	25	33	42	52	63	77
22	100	540	95			30	39	49	60	72	87
24	112	660	115			36	46	57	69	82	98
27	150	830	170			43	54	66	79	93	110
30	192	1,140	230			51	63	76	90	105	123

The acres drained is based on the removal of ¼ inch in 24 hours with a gradient of .001. Areas subject to heavy seepage from higher lands may discharge one inch from the wet area in 24 hours. In all cases it is assumed that a surface run is to be constructed large enough to remove the surface water from the upland surrounding the tiled land. Certain corrections have been made in Elliott's original table based on Yarnell's findings. The cost of the tile is f. o. b. any station in southern Wisconsin, Dec. 1, 1922, with 12½ per cent added to cover the cost of hauling about three miles to the trench. Labor includes digging the trench, laying the tile and back-filling, and good digging conditions are assumed. Cost of bulk heads, intakes, quicksand, stones or rock would have to be added.

Supplemental Assessments. Supplemental drains may be installed by the board upon petition of the one or more land owners affected by them. This usually necessitates the assessment of supplemental benefits. If the board omitted Lateral 3 from the original construction and put it in a few years afterward at a cost of $400, it would be necessary to deduct from the original tax and to levy later as a supplemental tax approximately these amounts:

SW NW Section 3	$160
NW SW Section 3	160
Town of Montrose	80

The benefits would be about twice these amounts in each case.

Additional Assessments. Construction may cost more or less than the estimate, depending upon the accuracy of the estimate or the success of the board in letting the contract. If the estimate is too small the board must levy another small percentage of the assessed benefits, but is not permitted to levy a tax in excess of them. Usually the board makes an original estimate large enough so that there is some money left in the treasury after construction is completed. This is used for maintenance of the drains. Open ditches must be cleaned out and repaired from time to time. If there is no money in the treasury the board may levy a maintenance tax of a few cents an acre each year known as "assessment for repairs."

The board acts virtually as a trustee of the project indefinitely. Its members are paid .66 cents an hour for the time actually consumed. At least one member of the board or a patrolman hired by the board should walk over and inspect each drain once every year.

The board may construct fences if necessary to protect the slopes of ditches. It shall also specify what kind of intakes are to be required to admit surface water to a ditch without erosion, and if a land owner violates an order of the board he is subject to a fine and payment of damages. It is good practice to seed grass on the ditch slopes and to level the spoil banks so that they are not a menace to the ditch.

Boards Aim to Please. Drainage boards and commissioners, as agents of the court, are guardians of justice to the land owners. In design of drain and expenditure of money, their aim is to give every land owner as much drainage as possible for his money. Disagreements may arise but the judgment of an experienced drainage board is usually better than that of a less experienced land owner. Often a land owner unconsciously opposes his own interest. The following statement by an experienced member of a farm drainage board illustrates the attitude of drainage boards:

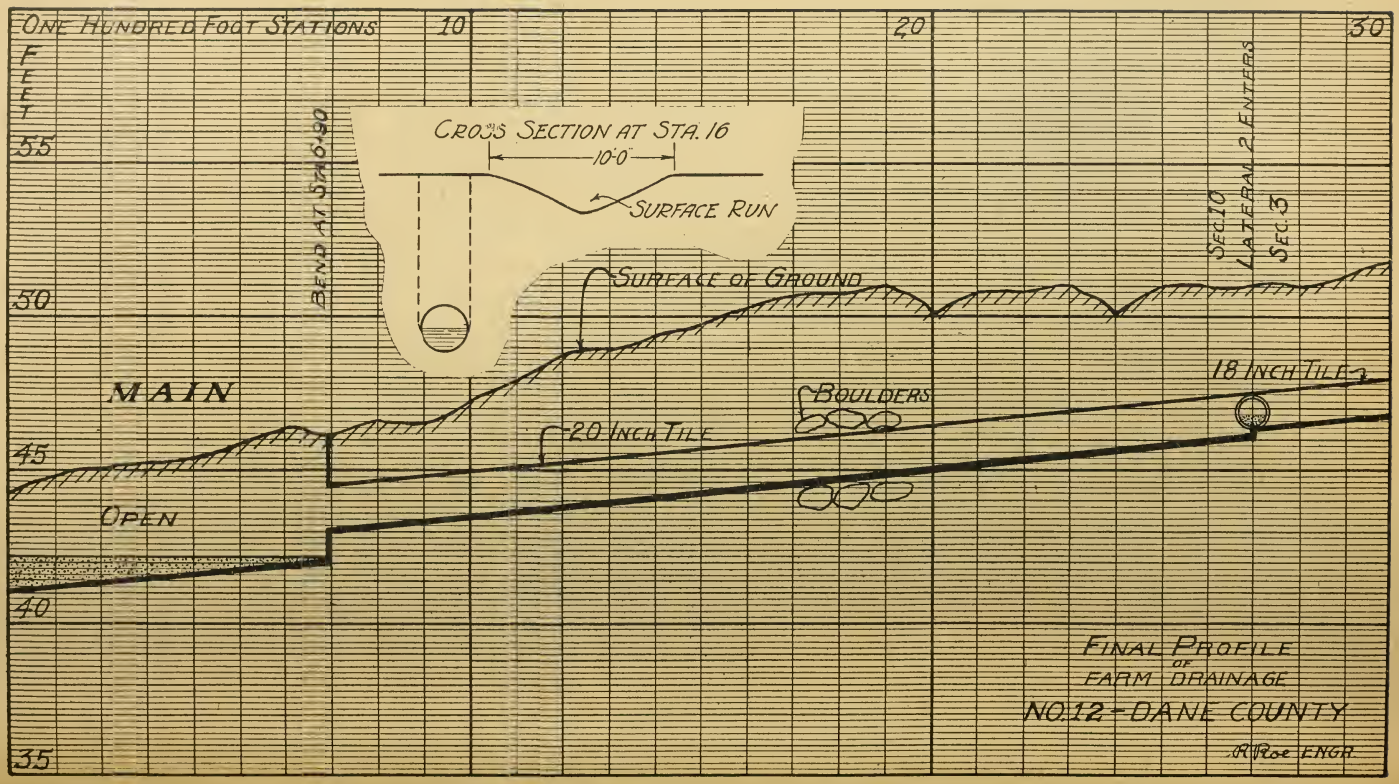


FIG. 22.—THE FINAL PROFILE

"In mingling closely with the land owners, one can also often overcome opposition. In one district by showing two objectors where we could turn the creek over on property lines and give them square pieces of land, we got the support of two of the most serious objectors.

At our meetings on the land, we call the roll of all land owners present. We then tell them that they have been called together to speak to the commissioners, not to argue among themselves while the meeting is in progress. We then call on each land owner to express his sentiments, at the same time informing them that their statements will be recorded and turned over to the court. When thus called on formally, the recorded answers are short and to the point. In this way, also, the land owners feel they have had their say and are not so apt to go to court. So far we have had only one remonstrance reach the court."

TABLE III.—ASSESSMENT OF BENEFITS AND DAMAGES.

1 Description	2 Section	3 Owner	4 Outlet benefits	5 Additional benefits for direct drainage	6 Total benefits	7 Assess for construction	8 Damages	9 Net assessment for construction
SW NW	2		$ 300.00		$ 300.00	$ 126.37		$ 126.37
NW SW	2		600.00	$ 160.00	760.00	$ 320.14		320.14
SW SW	2		600.00	260.00	860.00	362.26		362.26
SE NW	3		500.00		500.00	210.62		210.62
SW NE	3		1,750.00	160.00	1,910.00	804.55		804.55
SE NE	3		1,450.00	160.00	1,610.00	678.18		678.18
NE SE	3		2,000.00	480.00	2,480.00	1,044.65		1,044.65
NW SE	3		2,000.00	320.00	2,320.00	977.25		977.25
SW SE	3		2,000.00	600.00	2,600.00	1,095.20		1,095.20
SE SE	3		1,500.00	160.00	1,660.00	699.24		699.24
NE SW	3		1,200.00	160.00	1,360.00	572.87		572.87
SE SW	3		1,200.00	160.00	1,360.00	572.87		572.87
NW NE	10		1,200.00	160.00	1,360.00	572.87		572.87
SW NE	10		100.00		100.00	42.12		42.12
NE NW	10		900.00	160.00	1,060.00	446.50		446.50
SE NW	10		200.00	360.00	560.00	235.89	$ 10.00	225.89
NW NW	11		300.00		300.00	126.37		126.37
Town of Montrose			2,640.00		2,640.00	1,112.05		1,112.05
			$20,440.00	$ 3,300.00	$23,740.00	$10,000.00		$ 9,990.00

The ratio of cost of construction to benefits is .42. If there were any parcels not touched by an outlet drain it would be necessary to have an extra column headed: "Subtract for Necessary lateral." In that case outlet benefits would be assessed as if the parcel were touched by a drain and a subtraction would be made therefrom because of the omission of the lateral. Columns 4 and 5 are memoranda for the board and need not appear in the final assessment roll.

APPENDIX

INDEX OF DRAINAGE LAWS

The Drainage District Law is Section 1379, Wisconsin Statutes, or Chapter 557, Laws of 1919.

The Farm Drainage Law is Section 1368, Wisconsin Statutes, or Chapter 446, Laws of 1919.

The numbers in the index refer to the sub-sections.

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DUTIES OF THE ENGINEER

Preparatory Study

1. Observe the flow in the old creek.
2. Estimate the size of catchment basin.
3. Recognize the special merits of the project.
4. Recognize the chief obstacles.
5. Designate the forties to be included in the project and describe the plan that appears most feasible.

Preliminary Survey

1. Make a sketch showing approximately the edge of the wet land, using the forty-line as a basis if possible. If not, use transit and stadia.
2. Establish bench marks, and get the elevation of critical places as the basis for a preliminary profile. Look out for the low places hard to drain, usually some distance away from the drain. Make soundings for depth of water in ponds.
3. Study catchment basin more in detail and observe the size and kind of bridges.
4. Make borings of the sub-soil to a depth of 8 feet in critical places where drains will probably be.
5. Make preliminary plans computing the cost.

Final Survey

1. Stake out the drain with stakes every 100 feet, taking elevations at the foot of the stakes. (Do not set hubs yet.)
2. Compare two or more possible locations and decide which is the best, making borings to the proposed grade line to observe the sub-soil.
3. Take enough elevations located by transit and stadia that contour lines can be located at intervals of one foot; use these contours, supplemented with notes on the vegetation, for measuring the wet land. Check on the bench marks.
4. Make final map, plans and profiles and compute costs.
5. Help the board with assessments, and help the attorney with specifications for the contract.

Inspection

1. Set a hub at each stake on tile lines just before the contractor starts work. Cross-section and compute yardage accurately. For open ditches a hub every 500 feet on the center line is sufficient with a reference hub about 100 feet away from the center or far enough that it will not be disturbed by the dredge.
2. Give the contractor written grade notes and necessary instructions.
3. Stop the contractor and appeal to the board if unable to agree with the contractor as to methods.
4. Inspect all work each week so that the contractor can correct imperfections before his machine gets too far away.
5. Make monthly estimates of payments to be made to the contractor.
6. Recommend to the board any supplemental work proven necessary as the work proceeds.
7. Inspect drain tile when shipment arrives and reject unsatisfactory tile.

PETITION FOR FARM DRAINAGE

To the County Court of ..... County, Wisconsin:

The undersigned petitioners sufficient in number to comply with the law, desire to have organized under the Farm Drainage Law, a "drainage" as hereinafter described. We, therefore, respectfully represent:

(a) That the following lands will be benefited and should be included in the proposed "drainage:"

....
....
....
....

(b) That the proposed work is necessary and will be beneficial to the public health and welfare, because there is in the proposed "drainage" large amount of wet and marshy land affording breeding places for mosquitoes, causing infections, damps, and fogs, and having but little value for agricultural purposes.

(c) That there is attached hereto a sketch of the proposed "drainage" on a township plat showing the proposed boundaries of the same, and the general location of the proposed drains, subject to such changes as may appear advisable after the final survey is made.

(d) That we believe that the benefits of the proposed drains are greater than the damages and the cost of construction.

(e) That the name of the proposed "drainage" be ..... County Farm Drainage Number ..... (the number to be inserted by the County Judge).

(f) That we desire to have the proposed "drainage" organized with the least possible delay.

(g) That there { is / is not } (cross out one) filed herewith a guarantee for the payment of the portion of the cost of construction that may be in excess of the benefits.

(h) That (to be omitted where no old project exists) there was in the year ..... organized under an old state law a public drain within the area described in this petition and located approximately as follows: .....

.....

.....

Here follow the signatures of the petitioners:

....

....

....

....

PETITION FOR DRAINAGE DISTRICT

To the Circuit Court of ..... County, Wisconsin:

Your undersigned petitioners, sufficient in number to comply with the law, desire to have organized a drainage district under the Drainage District Law. We, therefore, respectfully represent:

(a) That the name of the proposed district is to be .....

.....

(b) That the proposed work is necessary and will be beneficial to the public health and welfare, because there is in the proposed drainage district a large amount of wet and marshy land affording breeding places for mosquitoes, causing infectious damps and fogs, and having but little value for agricultural purposes.

(c) That the accompanying sketch on a township plat gives a general description of the location, character, and plans of the proposed drains described more in detail as follows, but subject to such changes as may seem advisable in the light of the final survey:

(d) That the sketch attached hereto shows the boundary of the proposed district including approximately ..... acres described as follows:

....

....

....

(e) That the public health and the public welfare will be promoted by the proposed work and that we believe that the benefits will exceed the damages and the cost of construction.

(f) That the names and addresses of the owners and mortgagees of all land in the proposed district so far as known to us, is as follows:

....
....
....

(g) That we desire to have the proposed drainage district organized with all convenient speed.

(h) That (to be omitted where no old project exists) the purpose of the proposed work is to enlarge and repair an existing drain established in the year ..... and described approximately as follows:

.....
.....
.....

In testimony of our desires we hereunto affix our signatures:

....
....
....

FARM DRAINAGE NOTICE

State of Wisconsin,
County Court for Dane County,
In the matter of Farm Drainage Number 7, (Berry).

Notice is hereby given that the Drainage Board of Dane County, Wisconsin, will meet on the 6th day of April, A. D. 1921, at 10 o'clock A. M. at the home of....., in Section 35 in the Town of Berry, Dane County, Wisconsin, to consider the petition filed in the County Court for said Dane County: to drain lands in Sections Nos. 25, 35 and 36, in Township 8 North, Range 7 East, being in the Town of Berry, in said Dane County, and more particularly described as follows:

DESCRIPTION

Section 25,
NE¼ of NE¼
S½ of NE¼
SE½ of NW¼
NE¼ of SW¼
S½ of SW¼
N½ of SE¼
SW¼ of SE¼

Section 35,
NE¼
N½ of SW¼
N½ of SE¼
Section 36,
N½ of NW¼
SW¼ of NW¼

All persons may appear and be heard.

.....
.....
.....
Farm Drainage Board.

CERTIFICATION OF NOTICE

State of Wisconsin,
County Court for Dane County,

.....
In Re Farm Drainage No. 7 (Berry)
.....

State of Wisconsin, } ss.
Dane County, }

....., being first duly sworn, on oath says, that he is a member of the Farm Drainage Board of Dane County and that on the 23d day of March, 1921, he posted true and correct copies of the annexed notice of preliminary hearing to consider the petition filed in the County Court for Dane County as follows:

One copy of said notice on telephone pole on west side of highway running in a slightly northeasterly and southwesterly direction in the Southeast quarter (SE¼) of the Southwest quarter (SW¼) of Section Thirty-five (35) in said town of Berry, said telephone pole being approximately twenty feet southeast of the store and store building owned and occupied by .....

One copy of said notice on hog house abutting on east side of highway running in a generally northeasterly and southwesterly direction in the Northeast quarter (NE¼) of Section Twenty-five (25), said hog house being on lands owned and occupied by .....

One copy of said notice on cottonwood tree at north corner of highway four corners near the Southwest corner of Section 25.

That all of said notices so posted, were in Sections 25 and 35 of the town of Berry in said Dane County.

That on the said 23rd day of March, 1921, this affiant served a true and correct copy of said notice on each of the following named persons and owners of land within said farm drainage as follows:

One copy upon ....., by delivering to and leaving with the said ....., a true and correct copy of said notice.

One copy on ....., by delivering to and leaving with Mrs. ....., by this affiant known to be the wife and a member of the family of the said ....., a true and correct copy of said notice.

One copy on ....., by delivering to and leaving with the said ....., a true and correct copy of said notice.

One copy upon ....., by delivering to and leaving with Mrs. ....., by this affiant known to be the wife and a member of the family of the said ....., a true and correct copy of said notice.

One copy on ....., by delivering to and leaving with the said ....., a true and correct copy of said notice.

One copy on each of the following named persons: .....
.....
.....,

by delivering to and leaving with each of said persons, a true and correct copy of said notice.

Subscribed and sworn to before me this 26th day of March, 1921.

.....

Notary Public, Dane Co., Wis.

.....

In Re Farm Drainage No. 7 (Berry)

.....

MINUTES OF FIELD MEETING

The Dane County Farm Drainage Board met at the home of ..... in Section 35 in the above town of Berry pursuant to notice duly posted and served on April 6, 1921, at the hour of ten o'clock A. M.

The meeting was called to order at the appointed time by ....., president of the board, and proof of the posting and serving of notice was read by ....., secretary of the board. All members of the board were present.

On roll call of interested land owners, the following answered present: .....

.....

.....

The meeting was open for a general discussion of the drainage proposition and the following owners of lands were heard:

..... stated that he would like to know how the assessments were made, whereupon the board explained the manner of making the assessments.

..... stated that they didn't need a big ditch through his land; that a big ditch would be dangerous to cattle and that probably tile would be better, but that when a rain came tile would not be large enough.

..... stated that there was a lot of water in the neighborhood of his land all the time and that it should be drained out.

..... stated that the principal trouble would be the bridges over a big ditch and that the water might be stopped at the lower end by reason of the bridges.

..... wanted to know more about the manner of making assessments and further explanation was made relative thereto.

..... stated that he wanted to know more about the method and manner of making assessments.

..... stated that the proposition would be all right if the lands can be rid of the flood water.

..... said that his lands did not need a ditch; that he had a ditch on his land and that it was open; that he did not want a ditch unless he was paid damages; that his land was all dry and it

would be a considerable damage to him if the water was taken away.

..... made remarks similar to those of R. Jennickes.

..... stated that it would benefit his lands if they can be rid of the water.

..... said that he was at the upper end and did not think that his lands needed a ditch.

Mrs. ..... said that they constructed a ditch at one time and that the money expended was thrown away. She was afraid the result of this would be about the same.

The Farm Drainage Board thereupon checked over the acreage and signers to the petition and upon motion it was determined that the petition had attached to it a requisite number of signers.

There being no further business, upon motion made, the meeting was adjourned.

.....

Secretary.

SPECIMEN OF PRELIMINARY REPORT

State of Wisconsin,
County Court for Dane County,

.....

In Re Farm Drainage No. 7 (Berry)

.....

To the County Court for Dane County:

Now comes the Farm Drainage Board of Dane County, Wisconsin, and makes its preliminary report to the court relative to the above entitled farm drainage located in the town of Berry in said county, as follows:

That subsequent to the entry of the order referring the petition to the board and directing the board to report thereon, the board ascertained the sufficiency of the signers of the petition and with the aid of an engineer, approved by the State Chief Engineer, examined the lands in the petition and all other lands that the board believes will be benefited or damaged by the proposed work and considered whether the drains, as proposed, were satisfactory and had the engineer prepare a map, plan and profiles setting forth the outlines of the district and showing the location and character of the drainage which the board and its engineer finally considered as most satisfactory for the work covered by the petition herein.

That subsequently, and after due notice had been given as provided by law, a hearing on the petition was had as near the land described therein as convenient, such hearing being held on the 6th day of April, 1921, at the hour of ten o'clock A. M. on the farm of ..... in Section 35 in said town of Berry, at which time and place, the board gave opportunity for all persons to be heard who desired to be heard for or against the petition; that after personal examination of the

lands by the commissioners and their engineer and upon the report of the State Chief Engineer, the board reports as follows:

(a) That the petition is signed by adult persons owning a majority in acreage of the lands sought to be included within said proposed drainage.

(b) That the lands described in the petition will be improved by drainage and by the plan of drainage herewith submitted.

(c) That the plan of drainage proposed in the petition and herein recommended is feasible.

(d) That both the public health and the public welfare will be promoted by the proposed work.

(e) That the plan of drainage herein proposed, including any suggested changes in the report of the Chief Engineer, will best accomplish the drainage prayed for.

(f) That the benefits from such drainage will exceed the cost of construction.

(g) The board attaches to this report, proof of service of and notice of hearing on the petition, together with a copy of its minutes of such hearing marked Exhibits A, B and C.

(h) That filed herewith, are a map and profiles of the district and ditches prepared by the engineer of the board.

(i) That attached hereto, marked Exhibit D, is the report of the Chief Engineer of the State of Wisconsin on the location, design, feasibility and cost of the proposed work, a general description of such additional drainage is deemed necessary to properly reclaim said lands, a statement of a comparison of the benefits to the lands in different portions of the drainage, together with the report of the College of Agriculure of the state of Wisconsin.

WHEREFORE, the board prays the court to fix a time and place of hearing thereon and direct notice of such hearing to be given in the manner provided by law and for an order organizing said drainage.

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.....

.....

Farm Drainage Board of Dane County.

SPECIMEN OF SPECIFICATIONS

STATE OF WISCONSIN, COUNTY COURT FOR DANE COUNTY

Prepared by the Committee on Drainage, Wisconsin Enginering Society and the Committee on Specifications of the Wisconsin State Drainage Association.
In the Matter of the Farm Drainage No. .....

GENERAL SPECIFICATIONS

EXHIBIT "A" OF THE CONTRACT

I. DEFINITIONS OF TERMS AND EXPRESSIONS CONTAINED IN THE WITHIN SPECIFICATIONS.

1. The term "Map" shall refer to the blue print of the drawing of said "Drainage" which was filed in the office of the Clerk of the County Court for..... County by the Farm Drainage Board.
2. The term "Profile" shall refer to the blue print of the profile of the proposed ditches and drains within said "Drainage" and which was

filed in the office of the Clerk of the County Court for Dane County by the Farm Drainage Board.

3. The term "Contractor" shall refer to the person or persons or the corporation, or its proper representative, to whom shall be let the contract for constructing the work proposed in the report and in these specifications.

4. The term "Engineer" shall refer to such person as shall be employed by the Board to superintend under the direction of said Board the construction of said proposed work.

5. The term "Farm Drainage Board" or " Board" shall refer to the person or persons and their successors in office, who shall be appointed by the Court under Chapter 446, Laws of 1919, and the laws amendatory thereof, and who are possessed of the powers and charged with the duties, provided in Chapter 446 and the laws amendatory thereof, in relation to the organization of and the prosecution and completion of the proposed work of the said "Drainage."

6. The term "Station" shall refer to a point dividing the ditch or drain into sections of 100 feet each, and the stations shall be numbered consecutively from the outlet, which station is denominated zero, to the upper end of such ditch or drain.

II.

The starting point, route and terminus of the proposed ditch or drain and the location thereof as nearly as the same may now be determined, and which the said board may deem most proper and feasible for the accomplishment of the proposed work, are as follows:

(Here insert the location and design of the work referred to.)

III. GRADES

Grades shall be as shown on the profile and the contractor be furnished with a table giving the depth of cutting at all stations, such depth being measured from the top of the station stakes or hubs.

For open ditches a hub every 500 feet on the center line is sufficient, with a reference hub about 100 feet away from the center or far enough that it will not be disturbed by the dredge.

The location of the station stakes, the plans, profiles and excavation sheets as furnished by the Engineer, shall constitute essential parts of these specifications.

No work shall be accepted where the contractor leaves the line of the survey without authority of the Board.

IV. CHANGES AND ALTERATIONS

1. The location and dimensions of the drains shall be subject to change by and under the direction of the Board and their engineer.

2. The Board shall have the right to increase or decrease the amount of work on any part thereof, to such an extent as they may deem advisable and necessary, but may decrease it to an extent not exceeding ten per cent of the entire contract without agreement in writing by the parties to this contract.

3. Any increase or decrease in the amount of work shall be figured at the unit rate named in the proposal, and the value of the work included in such alterations shall be added to or deducted from the contract price as the case may be, and no allowance shall be made to the contractor, in the case of an increase or decrease of such proposed work, for any damages or loss of profits to the contractor occasioned thereby.

V. EXTRAS

The amount of the bid for the construction of the proposed work shall include all work, material used, tools, machinery, the removal and replacement of any sluice pipe, wire conduit or cable and all other matters necessary to complete the work according to the plans, profiles, and specifications, and shall cover all losses and damage to the contractor arising from any action of the elements, the nature of the soil or obstructions or difficulties which may be incurred in the prosecution of the work, and all losses and damages to the owners of lands resulting from any negligence of the contractor, in constructing said proposed work, and no charge for extra work shall be made unless it shall be ordered in writing by the Board or by the engineer with the approval of the Board and at a price therefor agreed upon previous to its commencement.

VI. MEASUREMENTS AND PAYMENTS

1. The profiles, maps and estimates herein referred to shall be considered as approximations only, but are sufficiently accurate to serve as a basis for bids although bidders for the proposed work must satisfy themselves by personal inspection as to the difficulties to be encountered in the construction of said proposed work.

2. Intermediate payments based upon approximate estimates of the engineer for work performed during the preceding month made during the first week of each succeeding month, during the progress of the work shall be payable about the 15th day of each succeeding month. Such payments shall be 85 per cent of the contract price of the work done the previous month, as estimated by the engineer, or such other percentage thereof as may be agreed upon, and the remainder of the contract price shall be paid within ten days after the completion of the entire contract to the satisfaction of the Board. No charge or damage shall be made or claimed by the contractor for delay or hindrance resulting from any reasonable or unavoidable cause during the progress of any portion of the work done, but it shall in the judgment of the Board be construed as entitling him to an extension of the time allowed for the completion of the work.

3. Unless otherwise agreed, the contractor shall at his own expense keep all work in good condition and repair until the entire contract is completed and accepted by the commissioners.

4. Before payments are made and before final acceptance and final payment for the whole of the proposed work the contractor shall be required, to the satisfaction of the Board, to protect the drainage district harmless against all liens for labor and material used in the construction of said proposed work and also against all claims for the use of patented articles, processes or appliances used in connection therewith, and against all claims or demands for personal injuries in whatsoever manner arising out of the construction of said proposed work.

5. No estimate of the engineer, other than the estimate provided by sub-section 2 of this section, shall be construed as a final estimate or acceptance of work done; nor shall any payment other than the final payment made after completion of the work to the satisfaction of the Board be construed as an acceptance of any work.

6. The contractor shall submit an itemized and correct statement of the cost of installing approved machinery and upon the satisfactory completion of such installation 90 per cent of such cost shall be due to the contractor.

VII. PROSECUTION OF WORK

The work provided for in the contract shall be begun at the time set forth in the contract or as otherwise determined by the Board and shall be diligently prosecuted in a workmanlike manner until its completion.

VIII. SUPERVISION BY CONTRACTOR

If the contractor shall not himself take immediate charge of the work in the field, he shall provide and designate to the Board and engineer a competent and experienced superintendent or foreman to take his place. In case the superintendent, foreman or other workman employed by the contractor shall neglect his or their duties or perform his or their work in an improper manner or shall persevere in misconduct after being warned by the engineer or Board the contractor shall discharge such superintendent, foreman or workman.

IX. GRUBBING

All grubbing or clearing of stumps, trees or brush, and the removal of all loose stone necessary for the construction of said ditch, shall be done by the contractor and shall be included in his bid for construction.

X. TREES AND BRUSH

All trees and brush within the area occupied by the ditch, berms and spoil banks shall be cut by the contractor and either burned or piled outside of that area before the spoil bank is deposited.

XI. ROADS

At the time of crossing any road or highway in the construction of any ditch or drain, the contractor shall erect barricades in such road or highway on both sides of ditch or drain at a distance of at least 200 feet from the point of crossing, and at such points that teams and vehicles may be readily turned and in the night time shall keep lights burning sufficiently adequate to give notice to travelers along such road or highway and to protect such travelers from injury. The contractor shall remove all bridges, the removal of which shall be necessary in the construction of the proposed work doing no unnecessary damage to the same and such barricades and lights as herein provided for in the case of crossing of roads shall be maintained until such bridges are reconstructed. The contractor shall further take all and every precaution necessary to protect the public from damage or injury in the construction of any ditch.

Upon crossing a railroad or other obstruction that would make it difficult to retrace the work with the machine, the board shall require the contractor to complete the work up to the point of crossing, permit the machine to cross, accept the work up to such crossing, and relieve the contractor of the responsibility of maintaining the accepted work.

XII. LEDGE ROCK

In case ledge rock shall be encountered in the construction of the work, the Board shall be notified immediately and will give instructions in regard to the removal of the same, and estimates and payments shall be based on the price bid for ledge rock. If no bid is made for ledge rock the board shall allow the contractor a fair price for such excavation.

XIII. FENCES

The contractor shall remove all fences the moving of which shall be necessary in the construction of said proposed work, and shall not cover up, destroy or do unnecessary damage to same.

XIV. SUPERINTENDING OF WORK

1. Directions shall be given in writing by the Board to the contractor, if present on the work, or to his superintendent or foreman in his absence, and such directions shall be received and obeyed the same as if given to the contractor.
2. Any work condemned by the engineer shall be remedied and in case the contractor shall refuse to remedy such defect as ordered then the Board may cause such condemned portion to be remedied or repaired under the direction of the engineer and deduct the expenses thereof from any moneys in their hands due the contractor.

XV. BRIDGES

In the construction of the said proposed work the following are the principal bridges that will be encountered:

.....

.....

Provision for the building of new bridges will be made by the Board and the construction of the same shall not enter into the contract for excavation.

XVI. DECISION OF BOARD

In the interpretation of these specifications and the contract and upon all questions concerning the execution of the work, the decision of the Board shall be final.

XVII. ABANDONMENT

If the contractor shall, at any time before its completion, abandon the work he has contracted to perform, he and his bondsman shall not be released from the provisions of part VI-4 of these specifications; but he shall remit to the board as liquidated damages all moneys then due him for work performed and he and his bondsman shall be liable to the district for all loss or damage occasioned by such abandonment and for any increased cost or expense to which the district may be put in completing the work according to the contract.

XVIII. BONDS

1. Upon being awarded the contract to perform the whole or any part of the work herein proposed the contractor shall give his bond conditioned for the full and faithful performance by him of such work and the payment for all labor and materials used under these specifications.
2. The amount of the bond shall be equal to one-half of the contract price and must be approved by the Board both as to amount, form and sufficiency of surety.
3. A copy of these specifications shall be attached to and made a part of the bond and no changes, alterations or modifications made in the plans or specifications, or in the contract entered into shall in any way release the contractor and his surety from the obligation of the bond; nor shall any acts of the Board or their engineers impair the obligation of the bond or be in any way a waiver of the rights of the "Drainage" with respect to the protection of the bond; but the bond shall be understood to be given for a completed job, in accordance with these plans and specifications and any changes, alterations or modifications made therein of whatever nature or character.

XIX. INDUSTRIAL INSURANCE

The contractor shall maintain such insurance as will protect him from claims under the workman's compensation acts and from any other claims for damages for personal injury, including death, which may arise from operations under this contract. Certificates of such Insurance shall be filed with the Board and shall be subject to their approval for adequacy of protection.

XX. BIDS

1. No bids or proposals will be considered unless accompanied by a guaranty, executed in an amount equal to 3 per cent of the amount of the bid, but in no case shall a guaranty of more than $500.00 be required, and all guaranties shall be subject to the approval of the Board. The guaranty shall be considered as liquidated damages and be retained by the district in case the contractor shall refuse or fail to enter into a contract as provided in these specifications, after acceptance of his bid by the Board.
2. The bids and guaranties shall be enclosed in a sealed envelope and endorsed "..... County Farm Drainage Board, Bids for Construction" and delivered at the office of the Board at the..... ..... Wisconsin. The Board reserves the right to reject any and all bids.

XXI. CONTRACT

1. A copy of the advertisement and of the specifications will be attached to the contract and form a part of it.
2. Any changes or alterations made in the plans or specifications shall constitute and be a part of the contract, and the same shall be considered as contained within the contract, although the same shall be made after the execution of such contract.
3. A transfer of the contract or of any portion thereof, or of any interest therein or the subletting of any portion of the work proposed to be done thereunder is prohibited without the written consent of the Board.
4. Within ten days after the successful bidder shall have been notified of such fact by the Board, such successful bidder shall be prepared and ready and shall enter into a contract with the Board for the construction of said proposed work.
5. The contract shall provide for the commencement of the work under such contract within thirty days after date of the execution of the same unless otherwise ordered by the Board.
6. The contract shall provide for the faithful and continuous prosecution of the work provided therein and for the completion of the same within the time to be determined therein by the Board upon consultation with the contractor.

XXII. EXPLANATION AND CORRECTIONS

Any doubt as to the meaning of these specifications and any obscurity in the wording of them will be explained by the Board, who shall have the right to correct any error or omissions in them when such correction is necessary for the proper fulfillment of their intention.

XXIII. CLASSIFICATION OF MATERIALS

Rock is defined as any material that requires blasting with dynamite or other explosive for economical excavation. All other materials shall be called earth.

OPEN DITCH

I. SLOPES

The slopes desired in all ditches are one foot horizontal to one foot vertical; should the contractor not be able to slope the sides in conformity to the above one to one form, he will be allowed to dig the sides in steps, but the inner angle of the steps must be outside of the proposed prism of the ditch so as to leave the ditch free of any material within the designed prism, and the bottom of the ditch shall not be so wide as to make the slopes too steep. (Make slopes 1½ to 1 in sand.)

II. BERMS

All material removed in the excavation of the ditches shall be removed to a distance of not less than 8 feet from the top of the slope of the adjacent side of ditch, unless a less distance is ordered by the Board.
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The berms shall be left practically free from all sods, roots, earth and other material excavated from the ditch. Any deviation of the edge of the ditch from a true line may be considered a defect and upon the order of the engineer shall be corrected without expense to the district.

III. SPOIL BANKS

1. All material removed in the excavation of the ditches and laterals herein provided for shall be placed on either bank in as nearly equal quantities as can be determined by ordinary care and shall be distributed evenly along the bank, except as herein provided and subject to such changes by the Board or their engineer as in their judgment the condition of the adjacent lands may warrant.

Whenever a spoil bank would obstruct the flow of surface water from a ditch or watercourse, the contractor unless otherwise agreed, shall furnish and install a flume or pipe to conduct the water from such ditch or watercourse to the bottom of the outlet ditch to to avoid erosion of the side of the ditch.

2. Where a ditch is wholly within the land of one person, or persons owning such land jointly or as tenants in common, openings in the waste bank on both sides of the ditch, at points directly opposite, shall be left, so that a private crossing may be had at such points as shall be agreed upon by the Board and the owner or owners of the land.

IV. MEASUREMENTS AND PAYMENTS

1. The material removed shall be measured by the cubic yard in the cut prism of the ditches, and the yardage shall be computed from the natural ground level, and no deductions will be made for old channels. The contractor shall furnish every facility for such measurements and will make no claim for any delay incident to such measurement. The engineer shall take accurate measurements upon the commencement and after the completion of the work, and from such measurements will determine the amount of material removed.

2. If the contractor shall construct any ditch wider or deeper than called for in the specifications, or wider and deeper than is otherwise agreed upon by him with the Board, such fact will not entitle him to increased compensation by reason of such increased width or depth and shall not lessen the berm elsewhere provided for in these specifications.

V. QUICK SAND

If quick sand is encountered in prism of the ditch the Board shall be notified immediately and may order the grade of ditch lowered one or more feet and continued at such increased depth until said sand disappears from the prism of the ditch, or until such increased depth is considered unnecessary by the Board, and the additional material removed will be paid for at unit prices. Any filling of the ditch because of quick sand after its construction in accordance with the directions of the Board shall not be cause for refusal to accept the ditch when completed. This provision applies wherever unstable soil is encountered.

VI. FLOATING DREDGES

The contractor has the right with the approval of the board to maintain dams to control the elevation of water for the practical operation of floating dredges and shall not be responsible for damages caused by the reasonable exercise of that right.

TILE

I. DETAILED SPECIFICATIONS

A. STAKES, STATION LINES AND GRADES: All trenches shall be dug accurately to the line and grade as given by an engineer, which shall be indicated by stakes set at station numbers, 100 feet apart or oftener as he may determine. The contractor shall protect and preserve these stakes and lines until the work shall have been completed. Any stakes, bench marks or other information unnecessarily or carelessly disturbed or destroyed by the contractor shall be reset at the contractor's expense.

B. QUICKSAND. If quicksand be encountered in excavating any trench, the work shall be stopped and the Board or engineer be at once notified. Instructions for the prosecution of the work will be given the contractor, and any expense caused the contractor by any change in plan or method of construction shall be determined by the engineer and paid by the board.

C. TRENCHING: The tile trenches shall be excavated on the line indicated and of such width and depth as shall be necessary to lay the tile to the grade line as given by the engineer. A sufficient space must be allowed between the side of the tile and the side of the trench so

that it may be properly blinded. No deviation from straight lines or curves will be permitted except by a written consent of the engineer or Board. In deep trenches, in soft material, bracing and sheeting must be used in order to properly protect the work during construction.

D. LAYING THE TILE: The laying of the tile must begin at the lower end and proceed up grade. The tile must be laid as closely as practicable and in lines free from irregular crooks, the tile being turned about until a close fitting joint is formed. When, in making turns, or by reason of irregular shaped tile, a crack of one-fourth inch or more is necessarily left, it must be securely covered with broken pieces of tile. Junction with branch lines must be carefully and securely made.

E. BLINDING TILE: After the tile have been laid and inspected, the tile shall be properly blinded with top soil and protected so they will not be disturbed when the trench is back-filled. In case the material in the trench is sand or other loose material, and is likely to run into the joints and fill the tile, the joints shall be protected by sod, top soil, good building paper or in such other manner as the engineer shall direct.

F. BACKFILLING: After the laying and blinding of the tile has been inspected, the trenches shall be back-filled even with ground surface, and the work may be done in any manner acceptable and satisfactory to the engineer. During freezing weather the filling must immediately follow inspection. In case the soil is suitable, the last spading in digging the trench may be thrown on top of the tile already laid and properly blinded with top soil.

In trenches more than 6 feet deep, no more than 6 feet shall be back at one time, and sufficient time shall intervene before the next filling to permit packing.

G. BULKHEADS: At the outlet of the main tile there shall be constructed a bulkhead of concrete according to dimensions as given on plans. The bulkhead shall be made in a form consisting of planks or boards closely nailed together. The proportions of concrete will be 1 cement, 3 sand and 5 crushed stone. The latter ranging in size from ¾ in. to 1½ in. or one part of cement and seven parts of clean gravel. The outside surface of the concrete must be spaded during pouring and after the forms are removed any rough places should be made smooth by filling in with mortar. Open outlets of the tile shall be protected by one-half inch iron rods placed vertically at a distance apart of not more than 2½ inches from center to center. The bulkhead must be completed before the laying of tile is begun unless otherwise ordered by the Board.

H. LATERAL CONNECTIONS TO MAINS: All lateral lines of tile shall have the top of the lateral level with the top of the main. Wherever it is necessary to connect a small tile with a large size without the use of a wye or a Tee, it shall be properly blinded with broken tile or by means of cement concrete. All junctions shall be made from the side of the main tile and not from the top. Lateral tile at a higher elevation than main tile will have the grade changed fifteen feet from the main tile, so as to approach the main at a steeper grade and intersect main tile at the side near the top.

K. QUALITY OF TILE: Drain tile shall be subject to the inspection of the engineer. He shall reject all tile that appear inferior on visual inspection. He shall then take samples of poorest of the superior grade and test them for strength and absorption, and if any of these samples has an absorption greater than 10 per cent of the dry weight of the tile or a supporting strength less than that of Extra Quality tile (A. S. T. M. Classification) the entire shipment shall be rejected. If the contractor desires a re-test, the engineer shall select the samples for the contractor to send prepaid to the State Chief Engineer, whose test and decision shall be final and binding.

In all soils except peat and sand under peat, press-made, steam cured, well mixed and well proportioned concrete tile shall be considered the equivalent of hard burned shale tile.

II. CHANGES AND ALTERATIONS

A. The location of a main or lateral or both, and the size of the tile shall be subject to change by and under the direction of the Board and its engineer.

SPECIMEN OF FINAL REPORT

State of Wisconsin,
County Court for Dane County,

In Re Farm Drainage No. 7 (Berry)

Now, comes the Farm Drainage Board of Dane County, Wisconsin, and files its final report in the above entitled drainage as directed by the order of the above entitled court dated December 12, 1921, and in accord with Section 1368—8 of the Wisconsin Statutes as follows:

1. That subsequent to the entry of the above mentioned order, the board, with the aid of an engineer, approved by the State Chief Engineer of the State of Wisconsin, proceeded to lay out drains of sufficient depth and capacity to adequately drain the lands proposed to be drained and in determining the depth and capacity of such drains, the board and its engineer considered the drainage of other lands lying above and draining in the direction of, through and along the general course of the proposed drain; and that the location, size, length, depth, grade and manner and method of construction of said drains are more particularly set forth in the specifications on file in the office of the board and attached hereto, marked Exhibit A, and by the blue print copies of the map and profiles heretofore filed in the above entitled court.

2. That in assessing the benefits that will accrue to the various parcels of land and corporations benefited and in assessing the benefits to farm lands, the board has ascertained and considered the depth, character and quality of the surface and sub-soils, the thoroughness and difficulties of drainage, the uses to which the land when drained will be adapted and all other elements that, in the judgment and knowledge of the members of the board, will enter into any increase in the value of such parcels of land resulting from the proposed work.

3. That the estimated cost of construction of said proposed work, as nearly as the same may now be ascertained, is the sum of $9,736.35 and amounts to approximately 46 per cent of the total assessments of benefits.

4. That damages should be awarded to such lands and corporations as in the judgment of the board will be damaged thereby and that the amount of such damages is the sum of $1,118.70.

5. That the names of the owners and the descriptions of the lands and corporations benefited and damaged, the amounts of the assessment of benefits and cost of construction levied against and the awards of damages awarded to such lands and corporations, together with the net assessment for construction against the same are as follows:

Names of owners and description of lands	Assessed benefits	Assessed for construction	Damages	Net assessment for construction
Sec. 24, T. 8 R. 7, Jacob Nonn, Pt. of NE¼ of NE¼ as Des. in Vol. 195 of Deeds Page 38	$ 188.10	$ 88.53	----------	$ 86.53
Frank Dermody, NE¼ of NE¼ less parcel Des. in Vol. 195 of Deeds Page 38----------	44.00	20.24	----------	20.24
Frank Dermody SE¼ of NE¼--	1,721.00	791.66	$115.40	676.26
----------	----------	----------	----------	----------

Here follows the rest of the assessment roll with totals for each column.

6. The above lands included within the proposed drainage lie between steep bluffs from which the waters will rush in considerable volume in times of freshets. If this water were uncontrolled and were permitted to flow over the berms and banks of the ditches, considerable erosion would likely result; that in the judgment of the commissioners at various places along the main ditch, it would be advisable to provide flood water inlets into the ditch by extending sewer pipes from the surface of the water to the surface of the ground outside of the waste banks, such pipes pointing diagonally down stream. The exact location of these inlets has not been determined but the cost of the same has been included in the above estimate of cost of construction.

7. That attached hereto and made a part hereof, is a report of the Chief Engineer of the State of Wisconsin marked Exhibit B.

8. The statutes permit the board, upon the approval of the court, to borrow money and issue bonds to meet the cost of construction and further permit that the assessments for cost of construction may be made payable at once or in annual installments not exceeding fifteen in number. The board is not informed as to whether any of the owners of lands and the corporations above described will be in a position to pay or will pay the whole or any considerable portion of the assessment of costs within a short period of time after the confirmation of this order, but the board is of the opinion that only a few, if any, will make such payments of the cost of construction. It is therefore probable that it will be necessary either to borrow money or issue bonds for the greater portion, if not all, of the cost of construction. For these reasons and in view of the present condition of the bond market, the board makes no recommendation at this time, believing that it will be to the advantage of the drainage to defer the issue of bonds as long as possible and therefore leaves the determination of the procedure to be followed in financing the work until the hearing of the court upon this report.

9. The board further reports that it will be necessary to borrow money at once to meet some of the expenses of organization prior to

the date that may be determined for issuing bonds or borrowing moneys for the payment of the cost of construction and recommends that it be authorized to borrow moneys for such purposes in such a sum and under such conditions as the court shall determine upon the hearing of this report.

WHEREFORE, the Farm Drainage Board of Dane County submits this report for the favorable consideration of the court.

Dated February ....., 1922.

(Signed) .....

.....

.....

Farm Drainage Board of Dane County.

SPECIMEN ORDER OF JUDGE

State of Wisconsin,
County Court for Dane County,

.....
In Re Farm Drainage No. 6 (Middleton)
.....

Whereas, the final report of the Farm Drainage Board of Dane County, in the above matter has been filed in this court and which report sets forth the assessments of benefits and cost of construction and awards of damages assessed against and awarded to all lands within said drainage;

Now, on motion of ....., attorneys for said drainage,

IT IS ORDERED: That said final report be heard and examined before this court on the ..... day of September, 1921, at ..... o'clock in the .....noon in the county court room in the court house in the city of Madison in said Dane County, at which time and place all interested persons may appear and be heard. All objections must be in writing and comply with Subsection 8 of Section 1368—3 of the Wisconsin Statutes.

Dated ....., 1921.

By the Court.

.....

County Judge.

SPECIMEN ADVERTISEMENT INVITING BIDS

Exhibit "B" of Contract.

Office of Farm Drainage Board of ..... County, Wisconsin.

....., Wisconsin, ..., 19...

Notice is hereby given that sealed bids will be received at the office of ..... in ....., Wisconsin, until ..... o'clock .... M. ....., 19..., for the construction of the following work in Farm Drainage No. .....:

Open Ditches.

.....miles .....cubic yards .....average depth .....max. depth.
.....miles .....cubic yards .....average depth .....max. depth.
.....miles .....cubic yards .....average depth .....max. depth.

Tile.

.....feet .....diameter .....average depth .....max. depth.
.....feet .....diameter .....average depth .....max. depth.
.....feet .....diameter .....average depth .....max. depth.

Extras.

.....
.....
.....

Maps, plans and specifications may be seen at the office of ..... or may be procured by writing to ..... at ....., Wisconsin. A certified check for ..... per cent of the amount of the bid, must accompany the bid, but in no case shall a check in excess of ..... be required. Bids may be on all or any portion of the work.

The board reserves the right to reject any or all bids.

(Signed) .....
Secretary Farm Drainage Board,
..... County, Wisconsin.

SPECIMEN OF AGREEMENT

State of Wisconsin, ...
County of ....
Farm Drainage .....

(Substitute "commissioners" for "board" in the case of drainage districts.)

AGREEMENT

Exhibit "C" of Contract.

THIS AGREEMENT, made and entered into this ..... day of ....., 19..., by and between ....., herein called the Contractor ....., and the Farm Drainage Board of ..... County in the State of Wisconsin, herein called the board, in accordance with an act of the legislature of the State of Wisconsin, being Chapter 446, Laws of 1919, and all acts supplementary and amendatory thereto.

WITNESSETH, That the Contractor.....for and in consideration of the sum of approximately ..... dollars, to be paid as provided in the Specifications, hereby covenants and agrees to and with the board as follows, to-wit:

ARTICLE 1. That the Contractor.....will construct and finish in every respect, in the most substantial and workmanlike manner, and to the satisfaction of the board and the Engineer appointed by the above named board to survey and superintend the work to be performed under this contract the following work at the following schedule of prices in accordance with the Plans and Specifications which are made Exhibit "A" of this contract. .....
.....
.....
.....
.....
.....

ARTICLE II. That the Contractor...will fully complete the said work not later than the ..... day of ....., 19..., and that time shall be the essence of this Contract; and that if the Contractor...shall fail to complete said work within the time above limited, ... shall forfeit and pay to the board as liquidated damages for such default the sum of ..... Dollars for every subsequent day that such failure shall continue, unless the time limit is extended for good cause by the board in writing.

ARTICLE III. That the Contractor....has executed a satisfactory bond to the board conditioned upon the faithful performance of this contract and saving the board from any loss due to the failure of the Contractor in his performance.

ARTICLE IV. That the Contractor.. agrees to start excavation on or before the ..... day of ....., 192..., providing he has been duly notified by the board that it has funds available to pay for the work as it proceeds.

IN WITNESS WHEREOF, The Contractor...and the board have hereunto affixed their signatures this ..... day of ....., 192...

.....
Contractor.

Witnesses:

....
....
....
..... Board.

In all of these forms for drainage districts use "District" for "Farm Drainage," "Commissioners" for "Board" and "Chapter 557 Laws of 1919" for "Chapter 446 Laws of 1919."

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
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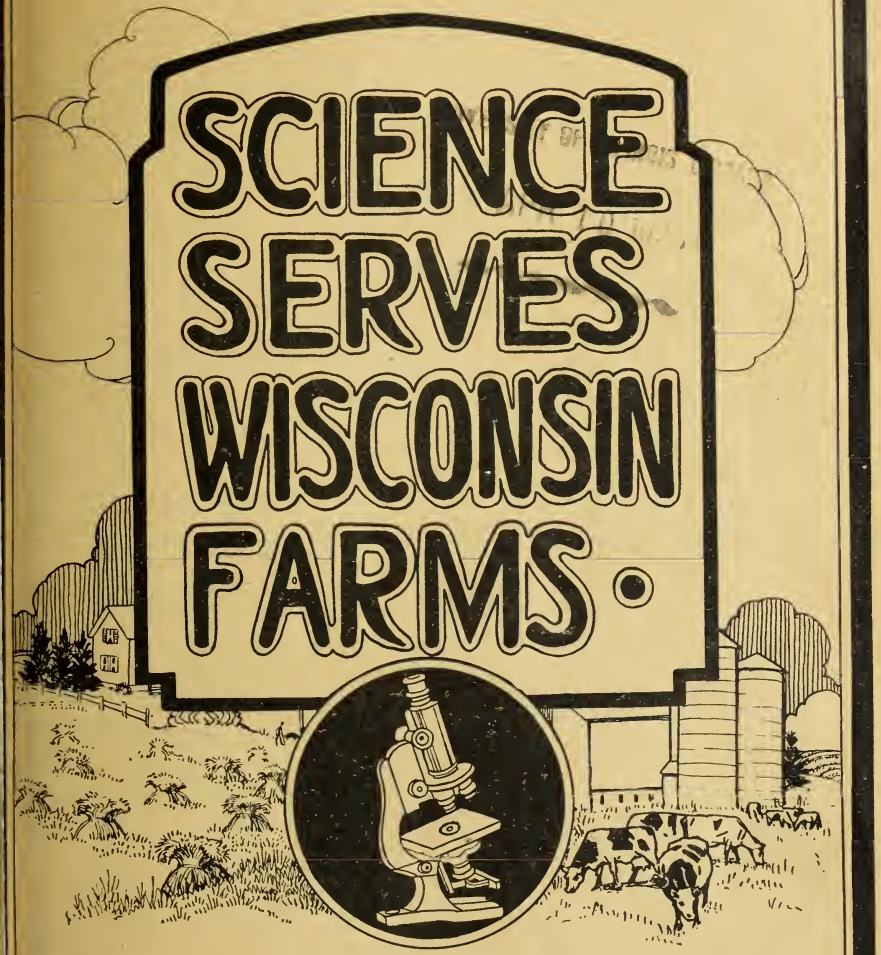
Bulletin 352 February, 1923

SCIENCE SERVES WISCONSIN FARMS



ANNUAL REPORT OF THE DIRECTOR
1921-1922
AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

FIVE FARM FACTS

1. Progress in agriculture is possible only through use of better methods.

2. Better methods can come only by finding and trying out new ideas.

3. The individual farmer has neither the time nor the money to work out many new ideas.

4. The State, therefore, provides the Experiment Station to do this work for the benefit of its citizens.

5. This report gives the reader the experimental results found and tested in 1921-1922.

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Science Serves Wisconsin Farms

H. L. Russell and F. B. Morrison

TOO OFTEN the business of farming is looked upon as merely the cultivation of the soil for the production of cereal crops. In Wisconsin, in earlier years at least, these were largely marketed as grain. More modern methods have shown the superiority of a system of livestock husbandry in which crop production is only one part of the industry. The *old system* developed grain farming with its loss of soil fertility and often unsatisfactory returns to the producer. The *more recent* system markets the crops through the medium of animals, thereby conserving the fertility of the soil and providing a better remuneration for the farmer. In these times, when the economic situation of the farmer is relatively trying because the post-war deflation of prices has greatly disturbed the balance of exchange values between raw materials, such as the farmer produces, and the finished commodities of commerce, it is of exceeding importance that the products of agriculture be marketed in an orderly fashion through the most suitable channels and in as nearly a finished form as possible.

We in Wisconsin have learned that livestock constitutes the mainstay of our agriculture. By marketing the products of the soil through the medium of our animal industry, this state has carried through the period of hard times in a manner which is second to none; and the livestock phase of our farming has become the ideal of many states less fortunate than ours. In the pursuit of this industry it has been well established that not only is good stock required, but it is of the utmost importance that the animals be well nurtured. In the conversion of field crops into animal products, feeding methods are of prime importance, and in this field the Experiment Station plays an exceedingly important rôle.

Modern methods have long passed the mere feeding trials of earlier days which simply compared one feed with another. More and more it is realized that the work of the chemist and the physiologist must now precede the labor of the practical feeder. The new discoveries in nutrition, many of which have come directly from the work of this Experiment Station, have given an entirely new concept to the whole field of animal feeding. Farmers now realize the part which vitamines play in the nutrition of livestock (even though their character is not

yet known); that the successful growth of animal life is quite as dependent upon the presence of these hitherto unrecognized substances as upon the energy-producing qualities of the feeds employed; and that success is best attained when these growth-stimulating materials are furnished in abundance.

For the purpose of rapid experimentation the chick with its early maturity offers peculiar advantages. The importance of the succeeding studies here reported is of special significance in Wisconsin agriculture as poultry is rapidly becoming an important and powerful adjunct to the dairy cow. In the decade between the last and the foregoing census, the value of poultry products in this state has increased 250 per cent. In 1920 the poultry output was over ten and three-quarter millions of dollars. In the last decade Wisconsin has passed both Michigan and New York in total poultry on farms, Wisconsin registering nearly eleven and one-half million fowls. In the period of stress through which agriculture is passing, no phase of farming has been more stable nor maintained better prices on the whole than the products of the dairy and the poultry yard. In pulling out of the present economic situation in agriculture, the state of Wisconsin can do no better than to combine the enviable lead which she already has in dairying with steady advance of other lines of the livestock industry in a highly diversified system of general farming.

THE KEEPING OF RECORDS and selective breeding have been among the primary factors in the success of Wisconsin's dairy industry. The average yearly butterfat production per cow in the United States is only 127 pounds. The average production of Wisconsin's cows exceeds that figure by nearly 50 pounds; while those in the Wisconsin cow testing associations reach an average of 265 pounds, a record equaling that of Holland whose development has long stood as a goal in the dairy world.

Similar achievements are possible with poultry. The average egg production of the United States (1920 census) was only 53 eggs per year. Wisconsin's production exceeds this average but slightly. At the Wisconsin Experiment Station 150 hens have averaged over 200 eggs per year, and 16 hens have individual records exceeding 250. Careful breeding and selection will increase profits in poultry as in the dairy industry.

Feeding Eggs to Baby Chicks Gets Results.

AS THE DAIRY industry has developed to a stage where a large percentage of the milk is produced during the winter months—a period during which the cows of the early pioneers were usually dry—so the poultry industry is rapidly going into the production of out-of-season eggs.

In order to produce winter eggs successfully it is necessary to hatch the pullets early in the spring so that they will be mature and capable

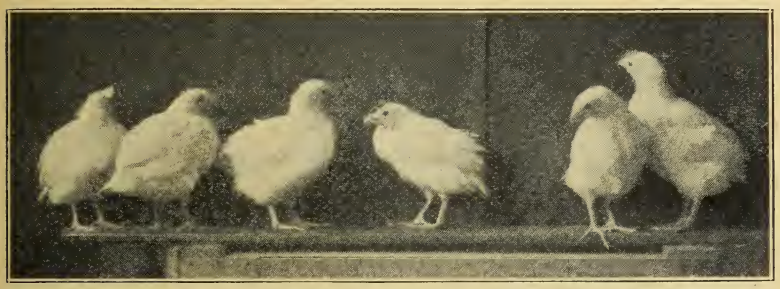


FIG. 1.—HEALTHY CHICKS AT SIX WEEKS OF AGE
These chicks were fed white corn, middlings, eggs, salt, grit and bone.

of laying during the period of high priced eggs. It is not practicable to force immature pullets for egg production, as a pullet must be well grown, well fleshed, and have nearly completed her adult plumage before it is desirable for her to start laying. If a pullet starts to lay too early only a few small eggs will be produced and then a false molt

FIG. 2.—CHICKENS NEED VITAMINES
This lot of six were fed a ration like the others except that they received no eggs. These chicks died shortly after this photograph was taken. A small amount of egg or other vitamine-rich food would have saved all of them.

with a two or three months rest period is likely to follow. November and December eggs bring the highest price, and consequently progressive farmers are hatching their chicks early enough in the spring so

as to have them well grown and ready to start laying in October or November. In raising early spring chicks, especially when it is done on a large scale, the problem of greatest importance is that of providing a proper ration. The speckled hen that in former days reared her nondescript brood in the summer months did not require much attention, for whatever deficiency may have existed in the ration was easily corrected by the food which nature supplied to the chicks; but the poultryman of today finds such methods impracticable.

In an effort to determine just what feeds are needed to grow vigorous chicks in large lots and in confinement, such as is necessary for

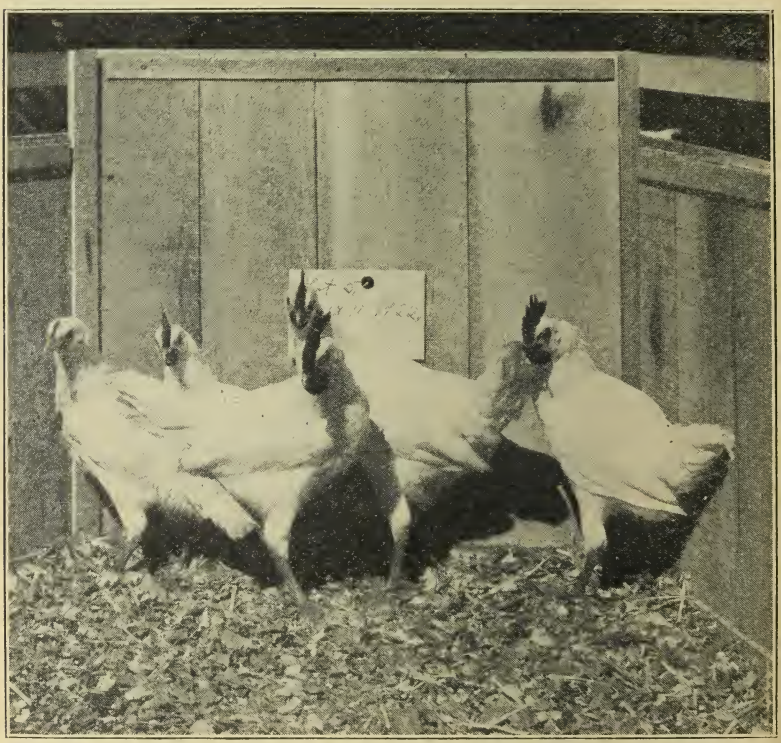


FIG. 3.—STRONG NORMAL CHICKS CAN BE GROWN IN CONFINEMENT

This group of chicks fed yellow corn, dried liver, middlings, lime, salt and skimmilk weighed 500 grams, or over one pound at seven weeks of age. They received no green or scratch feed, but the dried liver contained the necessary vitamines.

the profitable production of early spring pullets, J. G. Halpin (Poultry) and E. B. Hart (Agricultural Chemistry) undertook a series of feeding trials. The value of whole milk in the ration for baby chicks was one of the early findings, but subsequent work showed that skimmilk was not sufficient for growth except in certain combinations. It was

found that a ration of white corn, skimmilk and middlings would not produce proper growth, while the use of yellow corn and clover with skimmilk gave much better results.

Experiments conducted during the past year have shown that the addition of very small amounts of egg to the ration for baby chicks will give surprisingly good results. Chicks fed on white corn, middlings, and skimmilk grow for a few weeks and then die; but when one egg per day to each thirty chicks is added, normal growth results. Chicks fed yellow corn, middlings, and skimmilk grow fairly well, but not nearly so well as when eggs are added to the ration. The department recommends the use of infertile eggs from the incubator, or old eggs for the purpose; thus giving the poultryman an opportunity to utilize material that formerly was considered of little value. It is desirable to break the eggs into a dish with skimmilk and then beat the mixture thoroughly. The resulting liquid is used to moisten the mash of the chicks; feeding the eggs without beating makes the mash less palatable.

Where no milk is available, good growth can be secured by the use of eggs alone. About one egg per day to 30 chicks is the amount recommended during the first two weeks of feeding, but after that a gradual increase in the quantity of eggs used seems desirable. Ordinarily in chick feeding trials good results are obtained by the use of green feed in the ration; but when eggs are used, there appears to be no advantage in it. In case eggs are not available, whole milk can be used very satisfactorily as a substitute during the first three weeks of feeding.

Quality of Hatching Eggs Depends Upon the Ration

IT IS a well-known fact that to produce 100 pullets in the fall too many eggs are incubated in the spring. On an average about two eggs are used for each chick that is hatched, and considerable loss due to weakness of the chicks also commonly occurs. Poultrymen have long recognized this economic loss but have been powerless to reduce it. As the poultry industry slowly becomes more dependent upon commercial hatching, the importance of this factor becomes apparent, because the success of commercial hatcheries is almost entirely dependent upon the viability of the eggs which are incubated.

That factors, such as exercise, bear an important relation to the viability of the eggs produced by the flock has been generally believed. But last year J. G. Halpin (Poultry) and H. W. Steenbock (Agricultural Chemistry) began work to determine what influence the ration fed to hens had upon the viability of the eggs which were produced.

Though this work has been in progress only a short time, some surprising results have already been obtained opening up a relatively new field of research.

In these experiments pens of White Leghorn pullets, all of which were sisters from the same lot of eggs, were fed rations of white

corn versus yellow corn. Those fed white corn and casein gave an average hatch of only 15.3 per cent of the fertile eggs; whereas, when yellow corn was used instead of white, the average hatch increased to 23.6 per cent of the fertile eggs. When a vitamine-rich feed, such as pork liver, was added to these rations, the average hatch of the lot receiving white corn rose to 53.2 per cent of the fertile eggs and of the birds receiving yellow corn, to 62 per cent. When skim milk powder was used in the ration instead of pork liver, the white corn lot gave an average hatch of 20.9 per cent and the yellow corn lot 50 per cent of the fertile eggs. When dried pig's heart was used instead of liver, the results were no better than those from skim milk powder.

These experiments point unmistakably to the fact that such ingredients as yellow corn and pork liver exert a very potent influence in the ration of the hens if eggs high in hatchability are to be produced. In no case were satisfactory results obtained with rations low in the fat-soluble vitamine. These results have a definite bearing on the method of flock feeding where eggs are produced that are intended for hatching purposes. In late winter and early spring care must be taken to see that the ration used with the laying hen is sufficiently rich in this vitamine if a maximum production of hatchable eggs is to be secured.

Many successful poultry keepers believe that their hens should rest during the winter if they are to produce the best hatching eggs in the spring. They believe that market eggs should be produced by the pullets and only eggs from older hens incubated. The low hatchability produced by white corn and casein or white corn and skim milk rations was more pronounced during the latter part of the hatching season. This seems to show that to a certain extent at least a hen stores the vitamines in her body and gradually lays out her store unless it is replenished by the ration. For several years careful records have been kept of the viability of the eggs from different hens, and frequently hens that laid most during the winter produced the highest percentage of vigorous chicks. This seems to indicate that vigorous hens if mated to vigorous males and provided with rations sufficiently high in vitamine content should produce high priced market eggs during the winter and good hatching eggs in the spring.

Influence of Specific Rations on Animal Growth

Leg Weakness in Chickens.—Leg weakness in chickens frequently makes it exceedingly difficult to raise these birds well in confinement, and a further study of the problem has been made under the direction of Mr. Hart and Mr. Halpin. Though the roughage factor in the diet seems to be an important one, recent results indicate that the factor of primary importance in avoiding this trouble in the rearing of baby chicks under confinement is the provision of an ample supply of the fat-soluble vitamine—or, more accurately, those

vitamines contained in cod liver oil. With the water-soluble and antiscorbutic (anti-scurvy) vitamine supplied by white corn and skimmed milk, excellent and uniform growth was made by the baby chicks from an initial weight of 40 grams each to a final weight of 800 grams, provided the vitamine complex of cod liver oil was also available in comparatively generous quantities.

No leg weakness developed under these conditions. The birds were usually active and vigorous, and pronounced as normal specimens by experienced poultrymen. When the cod liver oil was withheld from the time of hatching, the growth ceased in four to six weeks, followed in many cases by sudden death. Occasionally the fowls con-

(A) (B)

FIG. 4.—THE DIFFERENCE BETWEEN WHOLE AND SKIMMED MILK

The larger chick (B) received white corn, wheat, bran, lime, salt and whole milk. It weighed 400 grams at the end of 8 weeks. The other chick (A) received the same ration except that skimmed milk was used in place of whole milk. It weighed 160 grams at the end of 6 weeks and then began to decline.

fined to a ration of white corn and skimmed milk grew for a longer period of time, but showed symptoms of nutritional disturbances, such as ruffled feathers, a squatting position, eye trouble, and leg weakness, which in all cases ultimately ended in premature death. From these experiments it appears that the considerable variations experienced in the rearing of baby chicks on various diets are due to the variation in the vitamine content of the food supply.

Blood analyses for inorganic phosphorus seem to show that rickets accompanied by low inorganic phosphorus content of the serum can be induced in this species, and while the term *leg weakness* may be used to cover a variety of symptoms and disturbances, it seems to be due to a low supply of the vitamine complex of cod liver oil in the

diet. It appears that it is in this connection that green material serves its extraordinary usefulness in the rearing of baby chicks, and that they can be reared with success under confinement when this factor is supplied from other sources. It is possible that even the introduction into the ration of tomatoes, rich in the three classes of vitamines, will be a practical solution of the problem.

Rickets in Swine.—Breakdowns in swine under certain conditions have been called rickets or rheumatism and, at other times, the effects of toxic material; but there has never been any very definite investigation as to whether these animals are subject to rickets or not. It

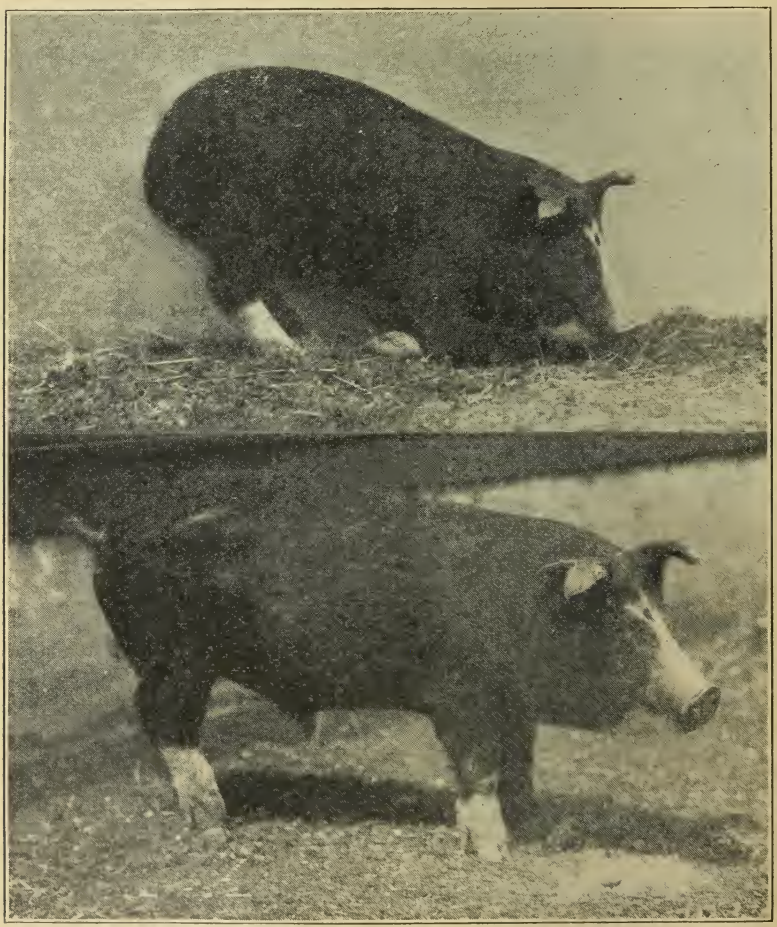


FIG. 5.—COD-LIVER OIL REVIVES RICKETY HOGS

Feeding white corn and skimmed milk brought on rickets in this pig (upper). When 10 c.c. of cod-liver oil were added to the daily ration, the animal recovered (lower).

has been shown that this condition developed readily from the use of certain grain rations and that it could be prevented by incorporating a fraction of certain roughage material, such as clover or alfalfa hay. Tankage also was used with success in avoiding it, while skim-milk used as a supplement to the grain or grain mixture alone always brought bad results.

Why alfalfa saved these animals from this trouble was a problem. Whether it was the effect of the roughage itself or whether it was due to some specific substance introduced by the alfalfa was not known. Studies so far made by Mr. Hart and H. Steenbock (Agricultural Chemistry) indicate that roughage itself will not save these animals from this trouble. Young growing pigs placed upon a ration of yellow corn, oil meal, floats, common salt, and *paper* showed distinct nutritional disturbances after three months on the ration. When cod liver oil was administered at the rate of 10 c. c. per day, it never failed to correct this nutritional deficiency, showing that probably the trouble was caused by a lack of a supply of antirachitic (anti-rickets) vitamine.

It has recently been shown in the study of rickets in children that during the height of the trouble the inorganic phosphorus content of the blood is greatly reduced. Invariably when the swine got into this condition without development of pneumonia, the inorganic phosphorus content of the blood has been low. Where the condition was complicated by pneumonia, this condition of low phosphorus content of the blood does not seem to occur. It appears also that rickets is likely to be produced in the winter feeding of swine when the ration is one of white corn and skimmed milk, and less likely to occur if the ration is made from yellow corn and skimmed milk, though this latter ration is not the best carrier of the antirachitic vitamine, and some pigs fail to do well on it. A ration made from any of the grains other than yellow corn and supplemented with skimmed milk only will cause trouble, and the mere addition of calcium salts does not act as a preventive, although it may delay the appearance of the disease. The trouble always yields to the feeding of cod liver oil even in the advanced stages, but the practical way to avoid it is to use some alfalfa or clover in the ration.

Chemistry of the Anti-scurvy (Antiscorbutic) Vitamine.—Work continued on the solubilities and fermentability of the antiscorbutic vitamine by Mr. Lepkovsky (Agricultural Chemistry) shows that this substance is soluble in water and alcohol but insoluble in chloroform, ether, ethyl acetate, benzine, and petroleum ether, which indicates that it is not of fat or lipoid character. It has been observed that it is not present in silage and that it disappears from sauerkraut. From studies made of its destruction by different fermentations, it appears that it is actually destroyed by certain organisms but not by others. The data obtained indicate that it is not a hexose sugar and that it is destroyed by certain types of organisms which are lactic acid formers. This explains why this substance disappears from such materials as silage and sauerkraut where such organisms predominate. The

fact that it is fermentable by certain types of organisms as ferment sugars would indicate that it may belong to the carbohydrates or closely allied substances.

Vitamine A in Whole Milk, Skimmed Milk, and Filled Milk.—In order to determine the distribution of vitamine A between whole milk and skimmilk. Mr. Steenbock and Miss M. T. Sell (Agricultural Chemistry) have devoted some time to this subject. The results obtained in the comparative growth of rats indicate that skimmed milk contained only about 20 to 25 per cent as much of vitamine A as whole milk. These figures vary somewhat from previous results, but they are considered somewhat nearer the truth.

The work in this connection was done with baby chicks to determine their capacity to grow upon rations low in fat-soluble vitamine. White corn and skimmed milk, and white corn and whole milk rations were used to bring out the difference between skimmed milk and whole milk in respect to their fat-soluble vitamine content. The chicks receiving the white corn and skimmed milk died in from four to six weeks, while those receiving the white corn and whole milk grew well without exhibiting the leg weakness or cessation of growth.

FIG. 6.—FILLED MILK DOES NOT MAKE ANIMALS GROW LIKE WHOLE MILK

The rat on the left received a purified ration plus 5 c.c. of whole milk daily and grew well. The one on the right received the same ration plus an equivalent of filled milk. Both are the same age; note the difference in size.

Trials have also been made to determine the nutritive value of whole milk compared with filled milk, using for the purpose one of the widely advertised brands. These experiments were conducted with rats from the same litter and with the filled milk diluted to the same solid content as normal whole milk. Also, the daily consumption of food has been alike in the two groups. As shown in Figure 6, the rats receiving the filled milk did not grow nearly so well as those receiving the whole milk.

Do Hay Curing Methods Affect Milk Cows?

IT HAS BEEN shown in experiments of the past, especially trials conducted by E. B. Forbes at Ohio, that milk cows, especially heavy milkers, are usually in a negative calcium balance where loss of calcium from the body occurs. This was even true when alfalfa hay was used in the ration.

The problem has been further studied under the direction of Mr. Hart; and in the earliest experimental work conducted with three cows placed first upon a ration of grain, silage, dry alfalfa hay, and later upon the same grain ration plus green alfalfa hay, the results were

FIG. 7.—CURING HAY UNDER CAPS IMPROVES THE QUALITY

Protection from sun and weather preserves the vitamines which are so essential in animal nutrition.

then contrary to those made by the previous investigators. A positive calcium balance was obtained on dry alfalfa hay and a more pronounced positive calcium balance on green alfalfa hay. This is in harmony with the theory that green material has a more abundant supply of the vitamine assisting in calcium storage.

In order to verify the work another trial, modified to some extent, was carried on. Three cows were again used and fed on definite rations as follows: (1) on a silage and grain mixture plus timothy hay; (2) on grain, silage, and dry alfalfa hay; and (3) on grain, silage, timothy hay, and steam bone meal. On all of these rations negative calcium balances were observed, which was in agreement with the work of the earlier investigators and contrary to the results of the previous year.

In tracing the history of the alfalfa hays used in these two experiments, it was found that the one by which a positive calcium balance was established had been cured under caps and not exposed unduly to the weather. The second alfalfa hay used had been cured on the Hill Farm in windrows and exposed to the sun and weather for several days. It is tentatively suggested that in this difference of curing lies the cause of the difference obtained in the results of the feeding trials and that the method of curing will determine the content of the vitamine influencing calcium assimilation. Correspondence with Dr. Forbes elicited the fact that part of the alfalfa used in his early experiments was western hay, the curing process of which was unknown, and a part of it was hay produced in southern Ohio where the curing was done in the windrow. It appears from this that the nature of the curing processes of hay may be of considerable importance in determining its intrinsic feeding value from the standpoint of mineral metabolism. Of course, further study will be necessary upon the subject to check these results.

Mineral Metabolism of Milking Goats.—To determine the influence of certain natural foods upon calcium assimilation, work has been continued by C. A. Hoppert (Agricultural Chemistry) with goats. With grain and straws negative calcium balances were established; and then there were added to the ration various amounts of cabbage, yellow carrots, and the alcoholic extract of alfalfa hay. In this year's work, as in previous experiments, no influence upon the calcium assimilation was observed by the feeding of a large amount of fresh cabbage or yellow carrots. The animals remained in practically the same negative calcium balance as when these materials were left out of the ration.

When the alcoholic extract of alfalfa was fed, however, there was a distinct change which indicated that something had been dissolved out of the alfalfa hay, which, when added to the ration, had a decided influence upon the calcium storage. It is believed that with this work some light may be obtained on the effect of the curing processes of the various roughages on their calcium storage efficiency.

Recent Studies in Vitamines

Relation of Vitamine A to Rickets.—Following the trials of a year ago, when an eye (ophthalmic) reaction was demonstrated with dogs, which were kept on a ration low in vitamine A, various experiments by Mr. Steenbock and J. H. Jones (Agricultural Chemistry) have been carried out to ascertain the conditions necessary for normal bone development. The criteria upon which conclusions have been based have been the appearance of the animal, the presence or absence of convulsive spasms (tetany), deformation of the chest as shown by the

thoracic arch formed by the fifth ribs together with sections of adherent breastbone (sternum) and vertebra, phosphorus and calcium of the blood, and ash content of the ether-alcohol extracted bones. These criteria have shown that as much as 60 grams of fresh green alfalfa or 42 c. c. of orange juice daily will not prevent rickets in rapidly growing dogs. The antirachitic substance, however, whatever it may be, shows in its resistance to destruction by saponification (soap

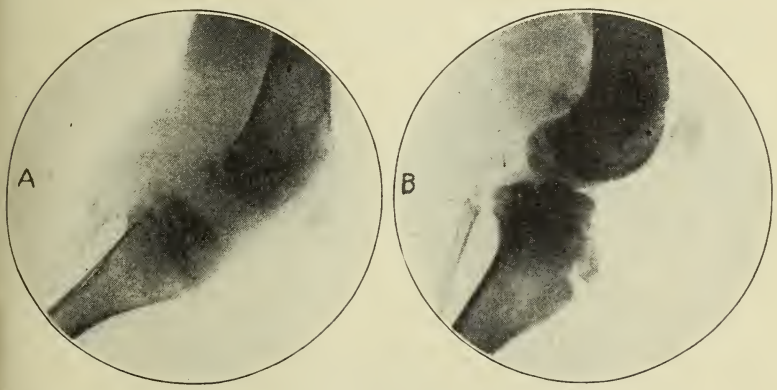


FIG. 8.—ABNORMAL BONE DEVELOPMENT IS A SYMPTOM OF RICKETS

The rachitic bone (a) is an X-ray picture of the left hind leg of a dog fed on a ration low in fat-soluble vitamine. Note the abnormal joint development.

The clean cut healthy bone (b) is an X-ray photograph of the left hind leg of a dog fed a ration like the one given the other dog, but 5 grains of cod-liver oil were added.

making) a property entirely analagous to vitamine A. This was determined by feeding two dogs twice saponified cod liver oil as a supplement to a basal ricket-producing diet. Calcification (laying down of lime in the bones) was found to be entirely normal.

Of late considerable evidence has been presented that, on diets tending to a deficiency of the antirachitic factor, rickets is induced most rapidly in animals kept in the dark. This has been verified in a trial with four dogs from one litter, two of which were kept in the dark with the result that failure occurred sooner with them than in those kept in the light. While all failed ultimately, lung deformations with attendant abnormal locomotion was first observed in the animals kept in the dark.

In order to demonstrate some of the effects of light on rats, Miss Jean Dow (Agricultural Chemistry), working under Mr. Hart, undertook a special study of this subject. She was able to sensitize rats to sunlight by feeding buckwheat, germinated buckwheat, or green buckwheat straw. When exposed to the light, rats fed buckwheat at first scratch and bite themselves; an abnormal redness of the ears, nose, feet, and tail develops; the eyes become swollen; salivation increases

to an extreme degree; and sometimes convulsions follow which terminate in collapse and death. Animals kept in the dark remained perfectly normal.

The Origin of Vitamine B. Yeast has hitherto been one of the most important sources of vitamine B and the question was raised as to whether it produced this vitamine or merely absorbed it from its nutrient solution. Though scientists do not agree upon the subject, experiments carried out with organisms, such as *Bacillus tuberculosis*, *Azotobacter*, and others, have shown that they do not contain any of this vitamine when grown on a vitamine-free medium.

Does Diet Influence Concentration of Vitamine B in Milk? There remains no question but that milk is relatively much richer in vitamine A than in vitamne B with respect to the requirements of rats for growth. It has been thought that this might be dependent upon the composition of the ration from which the milk was produced. Experiments were undertaken in which the vitamine B content of the cow's rations was increased many times by feeding large amounts of wheat germ. On feeding the milk so produced at different levels of intake of this material to rats, no change in the vitamine B content was observed, which leaves unexplained some of the results obtained by other experimenters.

Alcohol and Acetone From Waste Materials

THE PRODUCTION of acetone and alcohol from agricultural waste products by bacterial fermentation has been continued by E. B. Fred (Agricultural Bacteriology) and W. H. Peterson (Agricultural Chemistry). Corncobs, oat hulls, and peanut hulls have been found to yield large quantities of fermentable sugars. From 100 pounds of oat hulls may be obtained 2 to 3 pounds of acetone, 5 to 6 pounds of alcohol, and 3 pounds of volatile acid. That eventually such waste of agricultural materials, as corncobs and oat hulls will be put to use in the manufacture of these commercial products seems probable. The process used in obtaining these materials is one of hydrolysis with dilute sulphuric acid (H_2SO_4), in which from 25 to 30 per cent of reducing sugars, mainly xylose, are produced from the dry weight of corncobs. The xylose sirup is readily fermented by an organism (*Bacillus acetoethylicum*) to produce various products. On this basis 100 pounds of corncobs yield about 2.7 pounds of acetone 6 to 8 pounds of alcohol, and 3.4 pounds of volatile acids.

Yellow Versus White Corn for Swine Feeding

IT HAS BEEN previously reported that yellow corn has proved decidedly superior to white corn for feeding swine not on pasture and fed such supplements as tankage, skimmilk, or linseed meal. This superiority is due to the fact that yellow corn contains considerable fat-soluble vitamine, while white corn has little or none. Ex-

periments on this question have been continued by F. B. Morrison and J. M. Fargo (Animal Husbandry) during the past year.

That white corn is an unsafe feed for young pigs in dry lot when fed with skimmilk alone was shown again in a trial conducted last winter. Pigs fed yellow corn and skimmilk gained 1.02 pounds per head daily at a feed cost of only $5.59 for each 100 pounds gain. On white corn and skimmilk one pig died within nine weeks from rickets and another was in such condition that he would have died in a few days. This pig was removed from the experiment and, when given a small amount daily of cod-liver oil, which is exceedingly rich in

FIG. 9.—WHITE CORN LACKS FAT-SOLUBLE VITAMINE

Above.—Pigs fed yellow corn and skimmilk from a weight of 65 lbs. These pigs, fed at the Wisconsin Station, are all thrifty and have made good gains.

Below.—Pigs fed white corn and skimmilk. Four of the pigs in this lot died, because of the lack of fat-soluble vitamine in the ration.

the fat-soluble vitamine, slowly recovered. At the end of the trial all but four out of the ten pigs in the lot had died or showed the effects of the lack of the vitamine.

This trial, together with the experiments previously reported, shows clearly that white corn and skimmilk alone do not make a safe combination for young pigs not on pasture. Well-grown pigs weighing 100 pounds or more may come through safely if fed this ration, though white corn and skimmilk alone cannot be recommended even for such pigs. In a trial carried on this last summer with pigs averaging 142 pounds in weight when placed on feed, those fed white corn and skimmilk made the satisfactory daily gain of 1.57 pounds, while those fed yellow corn and skimmilk gained 1.65 pounds. The pigs fed white corn and skimmilk required slightly more feed for 100 pounds gain than those fed yellow corn and skimmilk, but the difference was not marked. These pigs had been raised on excellent rations and had been on good pasture before the experiment started. Under such

conditions their livers and certain other organs undoubtedly had a considerable store of the fat-soluble vitamine at the beginning of the trial. This store carried them through safely to a weight of 250 pounds even on the ration of white corn and skimmilk.

How Can We Feed White Corn to Young Pigs in Winter? This question naturally arises in the minds of all who are raising white corn, and many farmers prefer some varieties of white corn to all others. To answer this problem a series of trials is being carried on. In the experiment conducted last winter, young pigs made excellent gains when only 5 per cent of chopped alfalfa was added to the unsatisfactory ration of white corn and skimmilk. This combination was tested out because good legume hay is especially rich in the fat-soluble vitamine, and it therefore appeared probable that a *small*

FIG. 10.—LEGUME HAY MAKES GOOD THE DEFICIENCY OF WHITE CORN

Above.—Pigs fed mixture of 95 per cent yellow corn and 5 per cent alfalfa hay with skimmilk. Average daily gain, 1.1 lbs.

Below.—Pigs fed mixture of 95 per cent white corn and 5 per cent alfalfa hay with skimmilk. This small amount of alfalfa hay has saved the pigs from disaster. All are thrifty and have made as good gains as those fed yellow corn.

amount of alfalfa hay might save the pigs. A larger proportion of hay was not used because the digestive tracts of young pigs are not well suited to handle such hays or other dry roughage.

This small amount of chopped alfalfa prevented any trouble from rickets or paralysis and the pigs were all thrifty. The alfalfa was chopped by running it through a silage cutter equipped with an alfalfa screen. Hay can be chopped sufficiently fine for all purposes at small expense on the farm by this method, and there is no necessity for buying alfalfa meal. Quite probably *chopped clover* or soybean hay would serve the same purpose as *chopped alfalfa*. If one does not

have a suitable cutter, he can scrape up the leaves and chaff from the floor where the legume hay is pitched down from the mow and mix this with the corn and skimmilk or other feeds to form a slop, thus forcing the pigs to eat the hay.

Brood sows will commonly eat plenty of alfalfa hay of good quality if it is fed uncut in a suitable rack where they have access to it at all times. Usually they do not like clover hay nearly so well as alfalfa. Young pigs will not eat much long alfalfa from a rack and often will not take enough to provide themselves with a sufficiency of the fat-soluble vitamine.

Efficient Rations for Fall Pigs

IN ALL the northern states an exceedingly important problem is to find rations which will make fall pigs grow approximately as well as spring pigs when fed properly balanced rations on good pasture. A few years ago animal husbandmen thought that a ration of corn and tankage was well-nigh ideal for growing and fattening pigs, but experiments by Messrs. Morrison and Fargo, as well as trials at other stations, have clearly shown that pigs fed in the dry lot on only corn and tankage will often become unthrifty, even though the corn is yellow corn. Just what the deficiency in this ration is we do not yet know. It may be there is some lack of vitamines, or the proteins may not be the most efficient, or there may be a deficiency in mineral matter. Whatever the difficulty is, it seems to be largely overcome by adding a very small amount of alfalfa.

Even better results have been secured where both alfalfa hay and linseed meal have been added to the corn and tankage for pigs not on pasture. In three different trials during the past year pigs fed yellow corn and tankage have gained .95 pounds a head daily on the average while those receiving linseed meal and alfalfa in addition have gained 1.21 pounds. With feeds at present prices the cost of 100 pounds gain was but $5.91 for the pigs fed the efficient combination of corn, tankage, linseed meal, and alfalfa, while it was $6.37 for those fed only corn and tankage. At first it may appear that this difference in rate and cost of gains is not very great, but sometimes it is enough to make the difference between profit and loss.

This ration has proved the best of any thus far used for feeding fall pigs where there are no dairy by-products available. This ration may be fed by either of the following two methods:

(1) Self-feed the corn separately in one compartment of a self-feeder. In another compartment of the self-feeder feed a mixture of 50 pounds tankage, 25 pounds linseed meal, and 25 pounds chopped alfalfa. The pigs will take about enough of this protein-rich mixture to balance their ration.

(2) Self-feed or hand-feed a mixture of all four feeds in the proper proportions to make a well-balanced ration for pigs of the particular age you are feeding. This method apparently produces somewhat the most rapid gains, but it necessitates grinding the corn.

Home-Grown Rations for Milk Production

IT IS A MATTER of much practical importance to determine whether dairymen can provide a simple, cheap, home-grown ration which will maintain high production. If just as good results could be secured from such a home-grown ration as from one containing a considerable amount of high-priced purchased concentrates, farmers could often greatly increase their profits. Without question, the main source of protein in an economical home-grown ration must be a legume hay, usually clover or alfalfa.

The results of metabolism trials by the Agricultural Chemistry Department have been previously reported in which it was found that, on rations of alfalfa hay, corn silage, and corn or barley, good dairy cows could be kept in positive nitrogen balance; i. e., without losing nitrogen from their bodies. When clover hay was fed in place of alfalfa, the cows lost nitrogen and their milk yield fell rapidly. This was because clover hay did not furnish sufficient protein to meet the needs of the cows for nitrogen nutrients.

To study further the effect of a home-grown ration in which alfalfa hay was the chief source of protein, Messrs. Morrison, Hulce and Humphrey have carried on feeding trials during the past two winters. In each trial a ration of alfalfa hay, corn silage, and a concentrate mixture of corn and oats was compared with a ration made up of the same feeds plus linseed and cottonseed meal. In the first experiment each group of cows was continued on the same ration throughout the entire winter period. This was done as it seemed possible that the home-grown ration might maintain a high production for a brief period, but that the amount of protein in the ration might be too low to keep up the production throughout the winter. In the second trial the double reversal method was used so as to eliminate the effects of the individuality of the cows.

In each trial the home-grown ration containing no purchased concentrates maintained the yield of milk and of butter fat as well as the ration to which linseed meal and cottonseed meal had been added. These trials, together with the results of the previous metabolism experiments, show that, when cows have plenty of choice alfalfa hay, there is no need of purchasing expensive protein-rich concentrates to keep up good production. This is due to the fact that alfalfa hay is sufficiently rich in protein to balance the ration. In these trials the nutritive ratio of the home-grown, alfalfa-hay ration was 1:6.8 to 1:7.1. For cows forced to maximum production on official test, it is undoubtedly desirable to increase the amount of protein in the ration by the use of protein-rich concentrates, even when plenty of choice alfalfa hay is available. With such animals the object sought is the largest possible yield of milk without much regard for the economy of production.

Feeding Trials With Beef Cattle

Baby Beef Production.—A fourth trial in the feeding and finishing of well bred beef calves for baby beef was conducted during the past year by J. G. Fuller (Animal Husbandry). Thirteen calves, ranging in age from 9 to 12 months and weighing from 600 to 650 pounds at the start, were fed in two lots for 140 days. When fed an average ration of 1.8 pounds of cracked corn, 2.6 pounds of crushed oats, 1.9 pounds of bran, .68 pound oil meal, 14.1 pounds corn silage, and 3 pounds of mixed hay per day, the six heifers in Lot I made an average daily gain of 1.6 pounds. The return for the lot was $27.87 over the cost of feed. Seven steers which were fed a fattening ration of 7.1 pounds cracked corn, 1.3 pounds oil meal, 14.7 pounds corn silage, and 3 pounds of mixed hay made an average daily gain of

FIG. 11.—BABY BEEVES THAT MADE A PROFIT

This lot of seven steers, fed an average ration of 7.1 pounds cracked corn, 1.3 pounds oil meal, 14.7 pounds corn silage, and 3.0 pounds mixed hay, made a return of $62.85 over feed cost.

1.8 pounds; and the lot made a return of $62.85 over the feed cost.

As in trials previously conducted, these experiments showed that under favorable feeding conditions young cattle will return a fair profit. From the results obtained in experimental work with baby beef extending over a period of four years in which seven different lots fed on different rations were used, it seems probable that the production of baby beef can be followed with profit in southern Wisconsin during ordinary times.

Sunflowers Versus Corn Silage for Fattening Steers.—In the past year a feeding trial was also conducted to determine the value of sun-

flower silage as compared with corn silage for fattening a medium grade of two-year-old feeder steers. Two lots of ten animals each were equally divided, and the trial covered a period of 154 days. The first lot was fed an average daily ration of 8.6 pounds of broken ear corn, 1.5 pounds cottonseed meal, 24 pounds of corn silage, and 3.1 pounds of mixed hay. The second lot was fed in exactly the same manner except that sunflower silage in equal quantity was substituted for the corn silage. At the beginning of the trial the average weight of the animals was 677 pounds, and at the close those in the lot receiving corn silage in the ration weighed 1001 pounds, and those in the lot receiving sunflower silage averaged 1004 pounds. The average daily gain for the first lot was 2.10 pounds and for the second lot 2.12. Hogs following these animals returned a pork profit per steer in Lot I of $5.70, and in Lot II $3.71, which becomes a large factor in the total profit made in these lots. When both lots were sold at the close of the trial at $8 per hundred weight, the profit per steer over the cost of feed for Lot I was $11.32 and for Lot II, $9.22.

From these returns it is calculated that sunflower silage was worth 78 per cent as much as corn silage for fattening two-year-old steers in this particular trial.

Feeding Trials With Draft Foals

UNDER ECONOMIC conditions, such as obtain in agriculture today, it seems rather surprising that good draft horses command the prices which are still paid for them. The value of the draft horse is, of course, largely determined by individual excellence. If the farmer raises horses at all, it will certainly pay him to raise only the best.

Proper feeding is one of the primary factors involved in the making of a good draft horse out of a high-class foal. In order to determine what rations are best suited for the proper development of the size and weight which is essential in these animals for ideal draft conformation, Mr. Fuller conducted some feeding trials on this subject.

A lot of seven purebred draft foals was fed for 182 days during the winter of 1921-1922 on an average daily ration of 11.4 pounds of concentrates and 6.4 pounds of alfalfa hay. The grain mixture consisted of 90 pounds of crushed oats and 10 pounds of wheat bran. The foals made an average daily gain of 1.9 pounds and averaged 1141.4 pounds in weight at an average age of 377 days. The result of this work checked very closely with the trials of previous years, and it appears safe to conclude that by proper care and liberal feeding, good draft foals can easily be made to weigh 1,000 pounds at one year of age.

New Index Shows Quality of Animal Body

ANIMALS of apparently the same size and type often differ considerably in weight. The age factor and the manner of growth, the relative proportion of bone, muscle and fat all bear important relations to the type of animal body; and very frequently the difference between types is not readily detected by the eye.

There has long been a need for some single index which describes with reasonable accuracy the type of animal. Especially in experimental work and breeding and feeding trials, weight measurements alone are unsatisfactory. C. R. Yapp, working in the Department of Genetics under L. J. Cole, has devised such an index which, under certain conditions at least, serves as a satisfactory description of type. This index is based on the proportion any animal would fill of a rectangular solid determined by the animal's major dimensions. The weight must be translated into volume, and the specific gravity of the animal also enters into the process. The specific gravity was determined directly by experiment with animals in the genetics herd. The formula worked out for this work is as follows:

$$I = \frac{H^2 \times L}{W \times 475.8}$$

Where I=the dimension-weight index;
H=height at withers;
L=length (horizontal distance between pinbone and point of shoulder);
W=weight of animal in pounds; and
475.8=constant for the volume per pound of the animal.

The application of this index to the growing cattle in the experimental herd, which have been measured and weighed at regular intervals during their lives, showed a gradual change in body type from birth to maturity. The average index value of calves one week old was found to be 7.9, and for animals at the age of 22 months, when they were approaching maturity, it was 4.7. The decrease in the index value was fairly regular and consistent, which indicates the gradual change of type as animals grow from birth to maturity.

In other words, the results of these experiments show that a calf one week of age occupies only 12.6 per cent of the volume of a rectangular solid determined by its height and length and that at the age of 22 months the animal occupied 21.2 per cent of the volume of a solid obtained in a similar way. It is believed that this index will be of considerable value in genetics as well as in different phases of animal husbandry work, such as teaching and experimentation.

Inactive Ovaries Cause of Male Plumage in Hens

EVER SINCE days of the Middle Ages there have been on record occasional cases of so-called egg-laying roosters. It was the usual custom in former times to explain phenomena of this sort by means of witchcraft, sorcery, or some other phase of the super natural. One case is on record where back in the fifteenth century

a so-called egg-laying rooster was brought to trial with due solemnity, found to be a sorcerer, and condemned to be burned at the stake.

Early in the spring of 1922, Mr. Halpin received a bird closely resembling a Brown Leghorn cock in plumage, but reputed to lay eggs The case was studied by the department of Genetics in coöperation with D. H. Reid of Poultry Husbandry. Previous investigations of L. J. Cole (Genetics) and W. A. Lippincott have shown that, when the

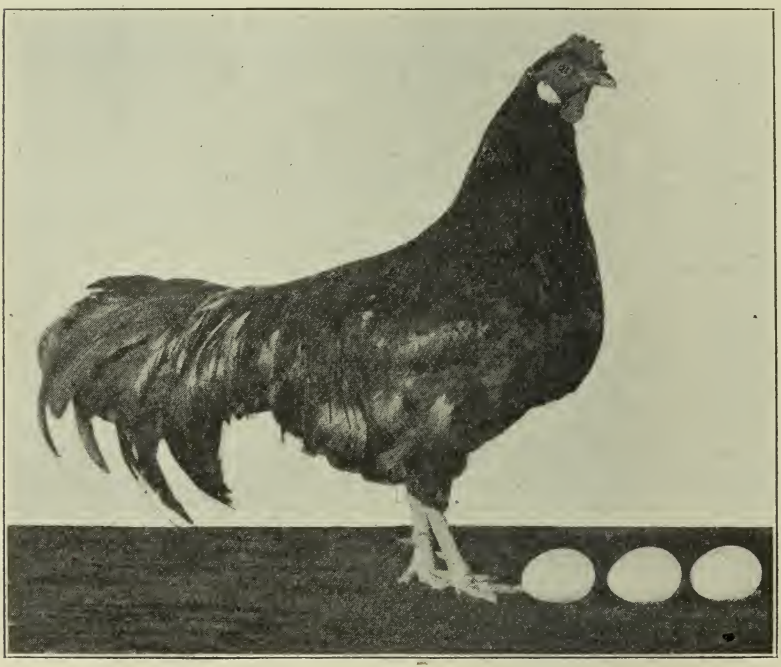


FIG. 12.—THE ROOSTER HEN AND SOME OF THE EGGS

This hen with cock plumage grew a new crop of normal hen feathers when she molted after her ovaries became active.

ovary of a hen becomes inactive through disease or otherwise so that it no longer supplies certain specific characteristics to the blood, the bird will, if she molts under those conditions, assume a characterstic male plumage. If active ovarian tissue is then introduced and a molt induced, the incoming feathers, developing under the influence of the ovarian secretions, will be hen feathers.

After a study of the case, it was decided that the ovaries of this hen had temporarily ceased to produce their usual secretion. As a molt had occurred during that time, the bird assumed clearly a male plumage. When subsequently the ovary resumed normal activity, egg production resulted; but there having been no molt during that time, the hen still wore her characteristic male feathers. When later

some of the feathers of this bird were artificially removed, new normal hen feathers grew in their place; and when a complete molt was undergone, the hen assumed a complete covering of normal female plumage.

Inheritance of Milk and Meat Production in Cattle

DEFINITELY planned experimental work for the purpose of finding how milk and meat characteristics of cattle are transmitted was begun by L. J. Cole (Genetics) in 1912. In order to support adequately any theory which may be formulated about the transmission of animal characteristics by inheritance, the number of individual animals involved and the number of generations observed must be relatively large. In the earlier stages of the work an Aberdeen-Angus bull was crossed with Jersey cows, and a Jersey bull with Angus cows. The result of these crosses was that the first generation of crossbreeds were all black polled like the Angus, but in most other respects were to a degree intermediate between the two, and there was a great deal of individual variation. The second generation offspring, produced by breeding the crossbreeds to one another, showed an even greater variation in type, especially in the matter of color and horns. These characteristics were inherited in definite Mendelian fashion, approximately three fourths of the second generation offspring being polled and one fourth having well developed horns.

Pursuant to the work conducted with the Jersey cattle, it was concluded that more definite information could be obtained by crossing Holsteins with Aberdeen-Angus in a fashion similar to that of the previous work for the reason that these two breeds exhibited greater differences in type than the ones formerly used. With this greater difference in type it was thought that the matter of tracing the courses of the various characteristics through successive generations would be less difficult. Accordingly in 1917-1918 work was begun in crossing Holstein and Angus. The results obtained in this work so far show the dominance of the black color, which is not unlike that of the previous experiment. The crossbred Holstein-Angus cattle were all black except for small areas of white, usually a small spot on the forehead, a little on the underline, and occasionally a little on the feet. The polled condition of the Angus is dominant over the horns as in the case of the previous work.

The Holstein-Angus cross-breeds are strong, quick-growing, relatively meaty animals; and it seems that, if calves were used for vealing purposes only or fed to an early beef age, something might be gained by breeding a herd of ordinary grade Holstein cows to an Angus rather than to a Holstein bull. Such cross breeding, however, *cannot* be advised if the calves are to be retained for breeding purposes. The milking qualities of such crossbred heifers will be determined as the experimental work progresses.

Breeding Improves Strains of Sweet Corn

THE WORK of breeding improved varieties of sweet corn for the canning industry in Wisconsin has been continued by E. W. Lindstrom (Genetics) and E. D. Holden (Agronomy). Over 200 rows of inbred pedigreed grain, field selections, and first and second generation crosses of the common sweet corn varieties were grown. Several of the inbred strains of Evergreen sweet corn have stood up remarkably well and will be used for future selection. In the process of inbreeding many of the poor characteristics have been eliminated from strains, though their vigor and yield have been maintained.

Of the Crosby sweet corn two distinct strains were isolated, one like the well-known Crosby, the other a variation of the 16-rowed type. From the Golden Bantam sweet corn an excellent strain has been obtained which proved to be unusually early and combined with vigor and high yield. Some promising material was also obtained from second generation crosses of hybrids produced from crosses between the various sweet corn varieties. When a crossbred corn produced

FIG. 13.—A FEW EARS OF INBRED GOLDEN BANTAM SWEET CORN

The defective kernels shown in the picture were brought to light by inbreeding this well-known strain.

from Golden Bantam and Evergreen and another produced from Golden Bantam and Crosby were again crossed, ears were isolated in which the yellow color of the Golden Bantam parents had been combined with the 12 and 16-rowed condition of the other parent. It is hoped that with a continuation of this work the fine quality of the Golden Bantam corn can be successfully combined with types of higher yield and better vigor than this strain now possesses.

The Effect of Inbreeding on the Kernel. Much emphasis was placed this year on the effect of inbreeding on kernel characteristics, and by this method several new types of hereditary defective kernels were isolated as shown in the photograph. These ears of the Golden Bantam variety came as a result of inbreeding a good commercial variety for three years. The original variety showed less than 1 per cent of poor kernels, while two-thirds of the ears of this strain showed defective kernels to the extent of 25 per cent on each ear after in breeding. Though these defective kernels will not germinate well the defects would never be eliminated by ordinary selection, which illustrates how poor characteristics may tend to remain in a common variety of corn and appear when close selection is practised.

Other types of hereditary abnormal kernels were found in flint, dent, and sweet corn; and there is probably a surprising amount of such abnormality in good varieties of corn. By careful attention much permanent improvement is still possible.

Breeding Jimson Weed for Higher Atropine Content

THE FIFTH year's crop of self-pollinated selections for high and low alkaloid content of the Jimson weed (Datura stramonium) was grown during the past season. The work served a two-fold purpose: it served as a study in inheritance in plants, and at the same time there are being isolated strains of the plants which are uniformly high in atropine content. (Atropine is an organic compound extensively used in medicine.)

The first generation of hybrids of the high and low testing strains was grown in cooperation with the Department of Pharmacy, and duplicate plantings of last year's selections were made also. The analysis of these crops showed that high and low selection lines remained separate so far as the production of the alkaloid was concerned.

Practically no work has been done to improve the qualities of plants grown for medicinal purposes. If this work proves successful, it opens up a new field for extensive experimentation in connection with the Pharmaceutical Experiment Station.

Alfalfa, Wisconsin's Best Hay Crop

THE GROWTH of more alfalfa is one of the ways in which Wisconsin farmers will find relief from the economic depression or after effects of the war. During the past two years some crops have been so low in price that after deducting the cost of production, the balance has often been on the wrong side of the ledger. All during this time alfalfa hay has been purchased by Wisconsin farmers at prices ranging from $20 to $27.50 a ton. With high market values and the possibility of producing yields of three tons or more

an acre, the financial advantages of alfalfa have appealed to many farmers who have begun growing this remarkable crop.

This situation has resulted in a tremendous demand for information about successful alfalfa growing under the varied soil and climatic conditions in Wisconsin. Several years of extensive investigations at the Wisconsin Station made by L. F. Graber (Agronomy) and numerous cooperative trials out in the state with the members of the Alfalfa Order have demonstrated that an abundance of lime in the soil, inoculation, good surface and under-drainage, a reasonable degree of fertility, a firm, well prepared seed bed and the use of early ripening or early removed nurse crops are the main essentials for success.

Alfalfa in the Sandy Sections.—Application of these principles to the growing of alfalfa has resulted in success on some of the light sand areas in the central part of Wisconsin. Experienced growers declare alfalfa a surer crop on a properly treated sandy soil than red clover because of the deeper rooting and greater drought resistance.

With the opportunity to produce from two to four tons of alfalfa hay an acre on the light soils, the sand farmer is finding his way to

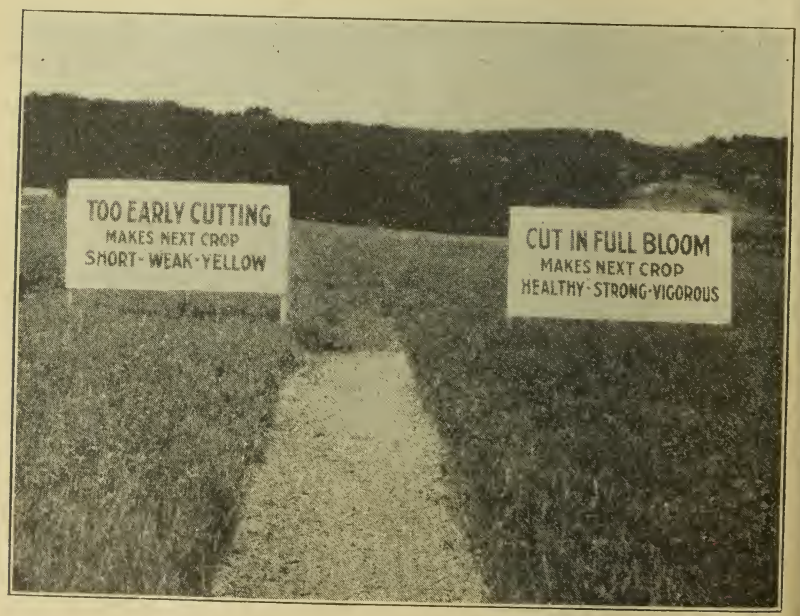


FIG. 14.—EARLY CUTTING WEAKENS ALFALFA, REDUCES STAND, INCREASES WEEDS, AND LOWERS YIELDS

The weedy area was a perfect stand of alfalfa, cut whenever it reached a height of from 4 to 8 inches. Three and four cuttings yearly exhausted the root reserves and permitted heavy weed encroachments. The alfalfa cut in the full bloom stage maintained a weed-free healthy growth and yielded in two cuttings 4.3 tons of hay an acre compared with a total of only 1.1 tons for the four very early cuttings.

profits which heretofore have not been realized and at the same time he is building up his soil to a higher plane of fertility which will make all other crops yield a greater profit per acre. Splendid success has been obtained with alfalfa on the sandy soils at the Hancock Branch Station, and on a measured acre at the Spooner Branch Station the average yield for four years has been over three tons per acre in two cuttings. On an old worn-out sandy soil in Green Lake County a stand of alfalfa was started five years ago by means of lime,

FIG. 15.—HEAVY ALFALFA ON LIGHT SAND

This alfalfa field near Plainfield, Wisconsin, yielded three tons of hay an acre and is an excellent example of what lime, inoculation, and manure will do on sandy land to make alfalfa doubly sure.

fertilizer, and inoculation, and has since produced continuously from two to three crops annually with a total yield of not less than three tons to the acre. At the time the alfalfa was sown, the average yield of rye on this field was from nine to eleven bushels per acre.

New Discoveries For Alfalfa Growers.—While the problems of getting alfalfa well started have required the greatest attention in the past, the maintenance of stand and yields in reference to the proper cutting stage appears to be of surprisingly great importance. During the past summer inquiries have come from farmers in various parts of the state in regard to the yellowing and short growth of the second crop of alfalfa on soils that formerly produced good, healthy alfalfa in abundance. Cutting trials conducted on the Experiment Station Farm by Messrs. Kraus (Applied Botany), Graber and N. T. Nelson (Agronomy) have given a satisfactory explanation.

Seven plots of one-year-old Grimm alfalfa were cut when partly in bloom on June 20, 1922, and an average yield of 1.0 ton per acre was obtained. Four days later five other plots of the same alfalfa were

cut with a yield of 1.3 tons per acre. The early cut crop seemed to do well for a time, but after about thirty days the leaves began to turn yellow, while the plots which were cut later continued to produce a healthy dark green growth. The second crop on all of these plots was cut on August 19, at which time the early cut alfalfa was only 8 inches high, decidedly yellow, and yielded only .35 tons an acre, while the later cut alfalfa reached a height of 13 inches and produced twice as much hay. Like results were obtained in three other trials of a similar character.

The alfalfa used in these experiments was sown on June 14, 1921, and cut three times during the month of August that year in order to check weed growth. It is probable that this frequent cutting together with the unfavorable winter weather which followed so weakened the plots of hardy alfalfa as to make them unusually sensitive to the cutting treatment. While in all probability the four days' difference in time between the cuttings of alfalfa two or more years of age would not produce such striking differences in yield, in trials at West Bend practically the same results were produced in two and three-

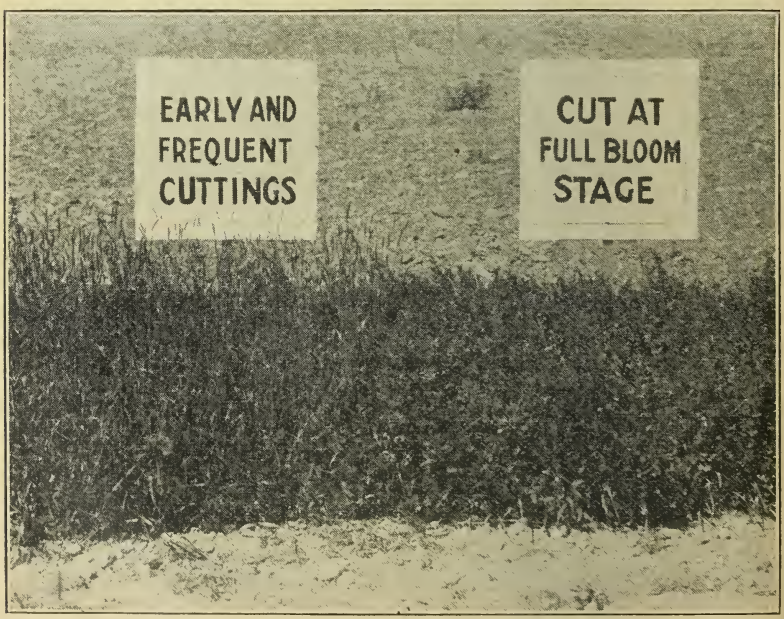


FIG. 16.—CUTTING FIRST CROP EARLY CAUSES "YELLOWING" OF SECOND GROWTH

Especially with new seedings and following hard winters alfalfa is sensitive to early cutting treatments. The later cut hay may be somewhat inferior in quality but to maintain yields, health, vigor, freedom from weeds, and permanence of stand require later cutting treatment than has been previously recognized. The yields of weed-free hay for the second crop here shown were reduced 50 per cent on account of early cutting.

year old alfalfa fields by allowing a difference of eight days in the cutting of the first crop.

Too Frequent Cutting Kills Alfalfa.—Trials were conducted with Grimm and Turkestan alfalfa where parts of these two-year-old plots were cut twice during the season at the full bloom stage, while other portions were cut three times at the early bud stage, and still other portions were cut four times at a much earlier period when the plants were from 4 to 8 inches high. The last cutting for all of these plots was made on August 21, 1922.

The results showed that the four-cutting treatment gave a yield of only 1.1 tons of hay per acre and practically eliminated the stand of alfalfa. After the first two crops had been removed, the plants rapidly lost vigor, turned yellow, grew very slowly, and became very weedy. Those plots cut twice in the full bloom stage maintained a thrifty, weed-free growth, and yielded 4.3 tons of hay per acre, while the three early bud cuttings reduced the vigor, thinned the stand, and gave a hay yield of only 3.0 tons an acre.

Two Crops Yield More Than Three.—The injurious effects of frequent cutting at very early stages, are beginning to appear on the station farm in the cutting trials which are being made at the three practical cutting stages; namely, the bud, "tenth", and full bloom stages.

Two year trials indicate quite clearly the wisdom of adopting a two-crop system in the management of alfalfa fields. This year two crops in the full bloom stage yielded 3.5 tons of weed-free hay an acre compared with an average of 1.9 tons of hay from three crops cut in the bud and "tenth bloom" stages. Following the hard winter of 1921-22 the full bloom plots comprising the three varieties—Grimm, Common, and Turkestan, have yielded 1.6 tons more hay an acre than has been obtained with three cuttings of these varieties at earlier stages. Further yields are indicated in the following table:

CUTTING TRIALS

With Grimm, Turkestan and Common Alfalfa (1921-1922)

Stage of cutting	No. of cuts	Average yields of cured weed-free hay an acre		
		1921	1922	Average
Bud stage	3	3.1 tons	1.8 tons	2.5 tons
Tenth bloom	3	4.4 "	2.0 "	3.2 "
Full bloom	2	4.4 "	3.5 "	4.0 "

The weakening effect of cutting alfalfa in the early stages shows itself in a natural decrease of the vigor of the plant and at the same time makes the crop more susceptible to winter injury when hard winters occur. These two factors seem to explain the rather paradoxical situation where two crops a season produce a greater tonnage than three.

Two Crops System Fits Wisconsin Farming.—Two of the great objections which have long been urged against the growth of alfalfa have been the competition which the harvesting of the first crop early in June occasions with the early cultivation of the corn crop during this critical period. It has also been claimed with much justice that the cutting of the first crop early in June has caused great difficulty in the curing process on account of the abundant rains and the natural succulence of the hay. Cutting alfalfa in the full bloom

FIG. 17.—MORE HAY FROM TWO CROPS CUT IN FULL BLOOM THAN FROM THREE CUT EARLIER

There are about three weeks between the bud and full bloom stages during which alfalfa may more than double its weight in dry matter. The picture shows the yield of the first crop from equal parts of Grimm alfalfa. When cut in the bud stage, the plot yielded 1.2 tons per acre; in the tenth bloom 1.8 tons; and in full bloom the yield increased to 2.9 tons. Total yield of season for two and three cuttings are shown.

stage obviates these difficulties. It delays the alfalfa harvest until about the last week in June at which time the weather is very often more favorable and the hay more easily cured.

It is true that alfalfa hay cut in the full bloom stage is of a coarser quality than that obtained from earlier cuttings and where soils produce an exceedingly rank growth of alfalfa and lodging occurs, it may be necessary to cut the first crop somewhat earlier in order to secure good hay. But because of the fact that the succeeding growths are usually much finer, they can often be cut in the full bloom stage. The first crop of one year old seedings of alfalfa is often very fine stemmed and can be cut at the full bloom stage without serious reduction in the quality of the hay and with considerable increase in the yields of the following cuttings. It is believed that where the alfalfa growth is very luxuriant on account of exceptionally favorable soil and climatic conditions, the plant does not appear so sensitive to early cutting as indicated in the previously described experiments. Generally speaking, alfalfa should be cut as near the full bloom stage as possible without getting the hay too coarse.

Cutting Off Young Crown Shoots Not Injurious.—For many years the warning has been sounded as to the danger of cutting alfalfa when the new crown shoots had reached a height where they would

be clipped by the mowing machine. It has been observed that, when alfalfa is allowed to reach the seed pod stage, many of these new shoots are 6 inches in height. Plots in the pod stage cut twice annually for the past two years showed no injury to the stand or vigor of the plants. These plots are now among the very best in stand and freedom from weeds. This work justifies a change in statement as to the supposed injury from the cutting of crown shoots.

Root Reserves Produce Frame Work.—In the proper functioning of the alfalfa plant the crown and roots develop certain food re-

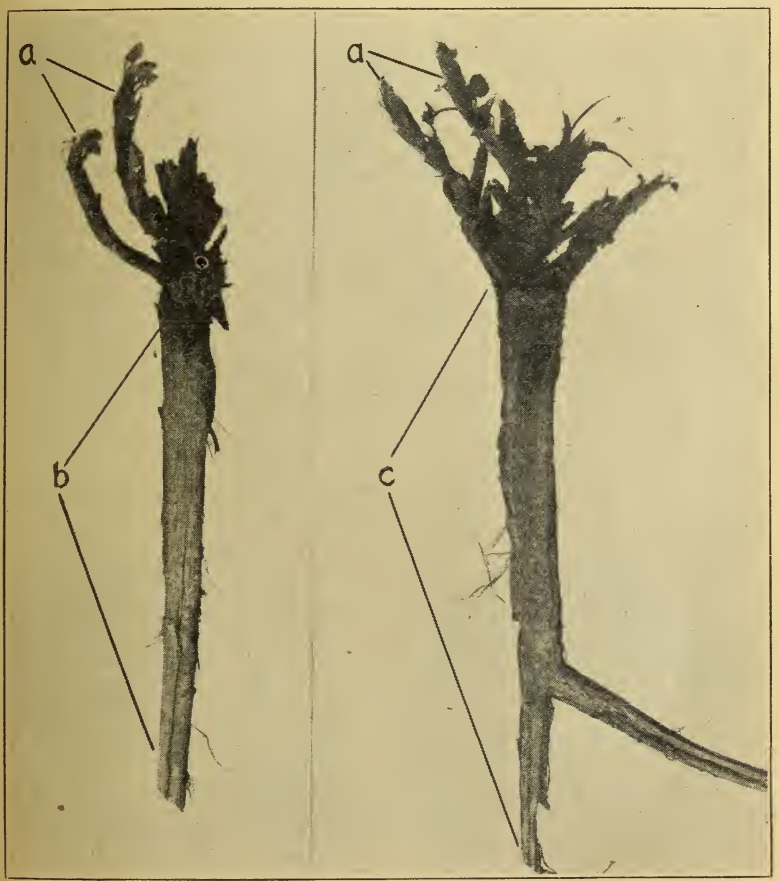


FIG. 18.—ALFALFA SHOOTS ARE HARDIER THAN THE CROWN OR ROOT

In many instances shoots that produced healthy leaves were found to originate from crowns which had completely winterkilled and decayed. As these crowns dried the source of food for the shoots was cut off and they gradually passed away.

(a) Healthy shoots from winterkilled and decayed crown.
(b) Healthy part of root.
(c) Winterkilled and decayed root.

serves which are stored up in these structures. If frost, drought, or cutting injures the old leaf structure, new shoots start to develop. These root reserves are used in the production of the *frame work* of the plant. When the blossom stage is reached, the old vegetation growth gradually ceases. The plant, through its leaves and stems, manufactures food materials not only to form the seed but also to replenish the root reserves which have been used in the growing process.

It is obvious that, when alfalfa is cut very early and frequently, there will follow a gradual exhaustion of these root reserves, which may cause a marked reduction in the ability of the plant to recover. This results in a stunted growth, yellowing, and may cause subsequent death. Apparently this is what occurred in the plots where frequent and early cuttings were tried. On the other hand, where the plants are allowed to reach the full bloom or seed pod stage, the root reserves are replenished, thereby giving great strength and vigor to produce increased yields and to eliminate yellowing and weed encroachment.

Scarify Alfalfa Seed Shortly Before Planting

THAT scarification is an effective means of increasing immediate germination of hard alfalfa and sweet clover seed has been repeatedly demonstrated. Samples of Grimm alfalfa giving a germination of 70 per cent and containing about 25 per cent of hard seed have been scarified and the viability increased to 90 per cent or higher. This process of scratching the hard surface coat of the seed so that it may germinate more readily is accomplished by forcing the seed by means of an air blast through a sandpaper lined tube, which removes particles of the outer seed coat.

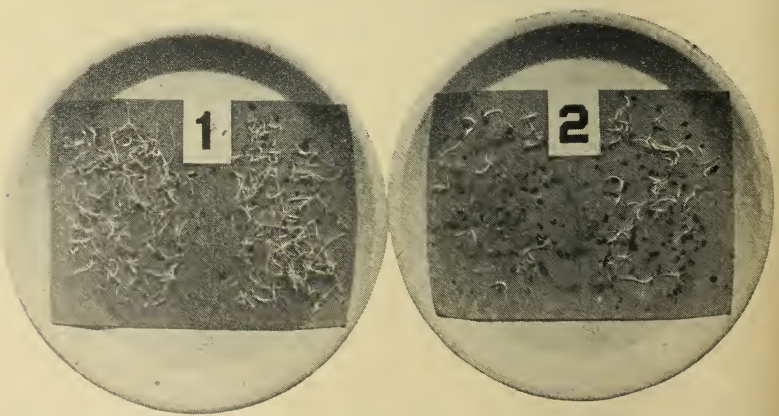


FIG. 19.—SCARIFIED SEED SHOULD BE SOWN WITHIN A YEAR

Both scarified and unscarified alfalfa seed were stored for three years in a cool dry basement. At the end of this period the untreated seed (1), which originally germinated 85 per cent, gave a test of 70 per cent. The scarified seed (2) with an original germination of 89 per cent dropped to 32 per cent.

While the effect of this process is to increase the immediate germinating power of the seed, recent experiments conducted by Mr. Graber show that this process has a very pronounced and detrimental effect upon the keeping quality of the seed. Scarified and unscarified seed of four lots stored in a cool dry basement for two and three years showed an average loss of 54 per cent in germination at the end of these periods while unscarified samples of the same seed stored under the same conditions maintained their original viability.

From a practical standpoint scarification is often used extensively for the improvement of the immediate germination of legume seeds, but where such seed is to be stored for more than one year, as sometimes is done in the seed industry and frequently in experimental work, the wisdom of delaying this treatment until a few months before seeding becomes very apparent.

Lack of Snow Causes Heavy Alfalfa Losses

INDICATIONS are that about 25 per cent of Wisconsin's alfalfa was lost last year through winter killing. The southern counties, where about 75 per cent of the state's alfalfa acreage is located, were practically devoid of snow. Periods of unusually low temperature and an ice sheet of unusual thickness and duration formed in February 1922, which caused the destruction of many thousands of acres of alfalfa of all varieties; in some cases even the hardiest strains were lost. The northern three-fourths of the state, where there was an abundance of snow, suffered practically no losses from winterkilling. The winter of 1920-21 also was characterized by a relatively light snowfall, but the alfalfa crops came through in splendid shape for the reason that they were not exposed to frequent low temperatures, smothering sheets of ice, or heavy fall and winter rains.

According to Mr. Graber, heavy fall rains in 1921 stimulated a succulent late autumn growth which in some varieties did not permit of the development of that protective dormant condition which is now believed to be so essential in the winter maintenance of alfalfa. An excess of soil moisture tends to increase the intensity of injury from alternate freezing and thawing. Furthermore, the favorable fall growing weather resulted in a great deal of late cutting in September 1921; some fourth crops of alfalfa were even removed early in October, a dangerous practice in Wisconsin.

Low Temperatures Injure Alfalfa.—Tests conducted by Mr. Graber and Mr. Nelson with alfalfa plants from four to sixteen months old of the Grimm, Turkestan, and common varieties in greenhouses gave significant results when exposed to low temperatures (—4°F.) twice in December and three times in January. The common variety was winterkilled to a much greater extent than were the Grimm or Turkestan; and when exposed to low temperatures, the younger plants seemed to suffer less than the older ones. In these

trials 84 per cent of the common plants were killed while only 18 per cent of the Grimm were lost.

When the injury of an ice sheet of a month's duration was added to that of low temperatures, the winterkilling of all strains was very severe—reaching 100 per cent in the case of common alfalfa and over 82 per cent with the hardy Grimm variety.

From these data it is evident that the frequent low temperatures may have winterkilled many bare fields of common alfalfa before the ice sheets occurred the latter part of February 1922.

Heavy Fall Rains Help Winterkilling.—Heavy rains in September, October, and November, 1921, compared with the light rains for the same months of the previous year seem to have had a distinct bearing on the winter injury of alfalfa during the past year. It is apparent that the accumulation of excess moisture in the soil augments the injury from low temperatures, alternate freezing and thawing, and heaving. In both experimental and field tests it has been noted that the winter injury was decidedly less on the high land where the surplus moisture could readily drain away than it was on the flat areas where the soil moisture accumulated. The theory is held that heavy fall rains and favorable growing weather tend to prevent the alfalfa from becoming dormant, in which state it is apparently less susceptible to winter injury, especially the weaker strains of common alfalfa. The hardier varieties, such as the Grimm, Baltic, etc., have a tendency to develop this state of dormancy regardless of weather and growing conditions.

Late Fall Cutting Injurious.—Three or four cuttings of the crop are often made in Wisconsin. When conditions are favorable, the plants may survive in spite of late fall cutting, but under adverse conditions—and one never knows when these conditions will set in—serious damage may result. In one trial late fall cropping increased the winterkilling of hardy Grimm alfalfa from 7 to 32 per cent and of common from 65 to 98 per cent. In another trial where three crops of common were cut in the full bloom stage 95 per cent winterkilling occurred compared to only 24 per cent winterkilling where only two crops of the common were removed. In this same test the removal of the third growth of Grimm in the full bloom stage increased the winterkilling from 8 to 24 per cent.

Late fall cutting not only increases the percentage of winterkilling but previous experiments have shown that it reduces the vigor of the following season's growth.

New Seedings Lessen Winterkilling Losses.—The age factor of alfalfa is an important one in reference to the winterkilling problem. Numerous tests of the station have shown that new seedings of alfalfa are much hardier than old stands. In this year's trials eight year old Grimm winterkilled seriously while adjacent plots of two year old Grimm, receiving the same cutting treatment, came through with very slight injury. The superior hardiness of the younger alfalfa offers a partial solution to the winterkilling difficulty. If the soil con-

ditions on the farm can be made sufficiently favorable so that alfalfa may be included in a four, five, or six year rotation, new seedings will be started every year or so and a total loss of the alfalfa acreage on the farm is not apt to obtain, particularly if the seed of hardy strains is used. In Jefferson, Waukesha and Green Counties, tremendous winterkilling losses occurred and to a considerable extent they have been due to a lack of new seedings. From 1918-21 inclusive, the

FIG. 20—NEW SEEDINGS OF ALFALFA AVOID WINTERKILLING LOSSES

A good stand of four-year-old Grimm winterkilled because of late cutting and the severe winter of 1921-22. A heavy growth of timothy and blue grass followed. Adjacent was a new seeding of Grimm which came through the winter with practically no injury. New seedings of alfalfa are much hardier than old. The inclusion of alfalfa in a regular rotation so that some new seedings will be established every one or two years reduces winterkilling losses.

old stands produced such abundant yields of hay that the necessity of new seedings was not felt. Where dependence is placed on old stands of alfalfa for the next season's crop, disappointment is very apt to be experienced when hard winters occur.

Location of Winter Injury in Alfalfa Plants.—An examination of several fields of alfalfa which looked quite promising in the month of April showed that they gradually dried up and died out as warm weather followed. What appeared to be a fairly healthy growth and good stand in the early spring vanished almost completely. An examination of 1600 plants from five to eight years old was made by Messrs. Graber and Nelson to determine the fundamental cause of this phenomenon. Three hundred and thirty-four of these plants had live green crown sprouts at the time the examination was made. The roots were all healthy and firm, but 34 per cent of the crowns were decayed

and soft, while the remaining 66 per cent were partially injured and rotted. In all instances living or green shoots of the plants could be easily pulled out of the rotted crown. During warm weather which normally would stimulate growth, the injured crowns or portions of the crown dried up and the sprouts soon died.

These results indicate that the buds and shoots are more hardy than either the crown or the root of the plant and that the crown and upper portions of the root, which are more directly exposed to climatic conditions, are the parts of the plant which first suffer from winter injury. A similar condition was observed by these investigations in fields of alsike and red clover that had suffered from winter injury and on which green sprouts appeared early in the spring, but later dried up and disappeared.

Emergency Hay Crops Often Help

BECAUSE of the excessive winterkilling of alfalfa and the clovers in the southern portion of the state, many farmers, especially dairymen, found it necessary to resort to emergency hay crops to provide suitable roughage during 1922. The work of G. B. Mortimer (Agronomy) extending over a period of years has shown that if right amounts and proper varieties of seed are used, there are a number of combinations which the Wisconsin farmer can successfully use to pro vide good quality hay by means of emergency crops.

Oats and Field Peas.—For an early seeded emergency hay crop a combination of oats and field peas is outstanding on soils adaptable to pea growing. During the past year yields ranging from 2 to 3 tons of air-dried hay per acre were secured. Though the quality of this hay was not equal to clover or alfalfa, it is readily eaten by dairy cattle and the digestible protein content is about equal to that of good red clover hay.

Sudan Grass and Soybeans.—Another year of trials has shown that a mixture of sudan grass and soybeans can be used to provide one of the most satisfactory emergency hay crops. The results obtained show that the most satisfactory rate of seeding is about 10 pounds of sudan grass and from 1.5 bushels to 2 bushels of soybeans. For this purpose the early varieties of soybeans seem to be best suited.

Sudan Grass Alone.—It has been demonstrated over a period of five years that the best results may be obtained by broadcasting or drilling sudan grass at the rate of 20 to 25 pounds of seed per acre. This rate seems to be most effective for seed production or for hay when this plant is grown alone. The crop has the additional advantages of making an excellent yield of hay even when sown at a time as late as the first week in July. As a smother crop to be combined with a partial fallow for the eradication of quack grass. sudan grass is unexcelled.

Soybeans Alone.—Excellent hay crops were also obtained during the past year by the use of soybeans alone. The use of 1.5 bushels

of seed per acre with Black Eyebrow variety gave the most satisfac tory results, over 3.5 tons of air-dried hay being obtained per acre.

The following table shows the results obtained from the various seeding rates and combinations:

TABLE I.—RATES OF SEEDING AND YIELDS OF EMERGENCY HAY CROPS

Combination and rates of seeding	Average in tons per acre
1.5 bu. Canada peas with 1.5 bu. oats	3.69
2 bu. Canada peas with 1.5 bu. oats	3.34
2 bu. Marrowfat peas with 1.5 bu. oats	3.11
1.5 bu. Scotch peas with 1.5 bu. oats	3.10
1.5 bu. Wis. Green peas with 1.5 bu. oats	3.32
1.2 bu. Scotch peas with 1.5 bu. oats—Kherson seeded latter part of May	1.95
10 lbs. Sudan with 1.5 bu. Black Eyebrows	3.46
10 lbs. Sudan with 2 bu. Black Eyebrows	4.04
10 lbs. Sudan with 2.5 bu. Black Eyebrows	4.00
10 lbs. Sudan with 2 bu. Hollybroods	4.30
10 lbs. Sudan with 2 bu. Manchus	4.69
1.5 bu. Black Eyebrows seeded alone	4.00
2 bu. Black Eyebrows seeded alone	3.91
2.5 bu. Black Eyebrows seeded alone	3.85

Seeding Clover and Timothy on Winter Grains

TO DETERMINE the best time of seeding clover and timothy on winter grains, trials were conducted by H. W. Albertz (Agronomy). The winter of 1921-1922 being an unusually open one, conditions were ideal for such work. It was found that clover seeding between March 1st and April 15th produced an excellent stand, while all others failed to do so. Timothy seedings between December 15th and April 15th all produced excellent stands. These results seem to show that seeding red clover on winter grains can be secured when alternate freezing and thawing of the ground occurs in the spring time, while timothy may be seeded any time after the fifteenth of December, provided there is no snow on the ground at the time of sowing.

Soybeans an Important Wisconsin Crop

THE SOYBEAN seems destined to become a crop of considerable economic importance in Wisconsin. A great deal of interest has been aroused in recent years in the growing of this crop, especially among the farmers on light and sandy soils. Some of them are now depending almost wholly for their silage, hay, and concentrated feeds on the soybean plant. For the beginner on light Jack-pine soils especially, this crop is an important one, because it grows well under these conditions and it can be put to a great variety of uses.

Experimental work with soybeans during the past year under the direction of B. D. Leith (Agronomy) has been confined very largely to the selection of the most satisfactory strains for seed production with some attention also given to the growing of the crop for hay. As a result of the experimental work at Madison, it appears that

the Manchu variety (Wisconsin Ped. No. 39) has on the whole given the most satisfactory yield, an average of 21.7 bushels being obtained during the past year and an average of 20.9 bushels for the past five years. In growing the plant for hay, a yield of 4.2 tons per acre was obtained from seedings at the rate of two bushels per acre with a grain drill. Ordinarily, however, considerable difficulty is experienced with the curing of soybean hay, and work on this subject will be continued.

Due to the rapid increase in soybean acreage in the state, an unusually large supply of seed has been produced. In former years there was considerable demand from surrounding states for seed, but as considerable quantities of this crop are now grown in these states the market demand for our surplus seed is limited. There will remain a considerable need of seed for seeding purposes, but other than a seed outlet must sooner or later be developed.

Flax seed production in the West is gradually declining, due largely to the ravages of the wilt disease. The problem of the adaptability of soybean oil as a substitute has been given much attention and much effort has been made by both the agronomy and genetics departments to improve the oil qualities of the soybean. To some extent soybean oil is now used in industry. Several mills have been established in neighboring states, but at present the oil interests are somewhat reluctant to establish the milling industry in Wisconsin. One of the problems has been to dispose of the soybean meal, which is a by-product remaining after the oil is expressed. Experiments have shown that this soybean meal has a feeding value about equal to that of linseed meal. In dairy states, such as Wisconsin, it seems probable that it should not be very difficult to dispose of this by-product, and it is possible that a satisfactory outlet for our surplus of soybeans may be obtained through the oil industry.

Cold Resistant Corn Fills Need of North

IN WISCONSIN and neighboring states there exists a general need for an early variety of corn which will produce a stalk growth large enough to enable farmers to fill their silos with a reasonable acreage. In order to meet this need B. D. Leith (Agronomy) has for several years been developing strains of Golden Glow (Wisconsin No. 12) by selecting it upon the basis of resistance to low temperature, early maturity, and stalk growth.

While practically one-half of the corn in Wisconsin at present is of the Golden Glow variety, it has been found that the new resistant strain is much more satisfactory in the northern counties of the state where the crop must needs encounter a much cooler climate than is found in the southern counties. Fields of this strain of corn grown in Forest and Florence counties seem to be fully as large as the Golden Glow which was grown on the Station Farm at Madison. The demand for this seed has become very insistent from Wisconsin and from neighboring states as well. A considerable amount of it has

been grown on northern soils and will be available for dissemination in 1923.

Through selection from ice box germination tests, Mr. Leith has been able to adapt this corn so that it will germinate and develop during the cool weather of spring or early summer.

FIG. 21.—SELECTING "COLD RESISTANT" SEED CORN

This field of "cold resistant" Golden Glow, grown by Roman Muskavitch of Shawano, yielded 111 bushels to the acre.

Germinated in ice box temperatures ranging from 42° to 50° F., ordinary Golden Glow corn only germinated 82.5 per cent as many kernels as this cold-resistant strain. Planted in the field with com-

mon Golden Glow on April 29th, 41.2 per cent of the cold resistant was ripe on August 23, 117 days after planting, while only 21.6 per cent of the ordinary Golden Glow was mature. This early germination and early maturity makes this type an especially valuable quality for northern needs.

In order to have this corn retain its cold resistant characteristics, it is necessary to grow it in the north where the environment is such as to maintain this cold resistant power.

Last year about 2500 bushels of this cold resistant corn were disseminated. The demand from other northern sections, such as Canada, North Dakota, Northern Michigan and Northern Minnesota, has been very great. In a few years more time it seems reasonable to believe that the silage problem for our northern dairy farms will be solved.

White Cross Oats a New Successful Strain

DURING THE PAST eight years efforts have been made to breed a new oats for Wisconsin, the object being to get an oat that had somewhat taller straw than the Wisconsin No. 7 and pure white instead of yellow. B. D. Leith (Agronomy) has now produced such a strain that has been named the White Cross oat (Ped. No.

FIG. 22.—A FIELD OF WHITE CROSS OATS
Earliness, high yield, and white color are the outstanding qualities of this new variety.

19) which has been grown in several parts of the state during the past year. The White Cross oat is a white kerneled oat and is much larger and heavier than the other early varieties. The oat stands up well on the richer soils, and it will be a valuable addition to our varieties of pedigreed oats. On an 8-acre field on the station farm, it produced 62.8 bushels per acre.

"Forward"—A New High Yielding Oats

THERE HAS recently been bred at the Ashland Station a new pedigree oats, *Forward* (Ped. 1241), by E. J. Delwiche (Agronomy). This new strain produced 56.3 bushels per acre or over 6.5 bushels more than its nearest competitor, and it led the well-known and commonly grown variety, Swedish Select oats, by over 17.5 bushels per acre. As an eight-year average, it has yielded 52.9 bushels per acre which exceeds all other varieties by an average of about 4 bushels per acre. Several hundred bushels of this strain will be available for 1923 distribution.

Oat Lodging Problems Studied

IN ORDER to determine the factors influencing the lodging of oats, work on this subject has been continued at the Marshfield Station by E. J. Delwiche. Observations during the past year plainly indicate that the variety used as seed is one of the primary factors concerned in lodging. Wisconsin Pedigree No. 1 (Wisconsin Wonder) easily takes first rank, showing practically no lodging in the experimental plots; Pedigree 1214 (White Russian) is second, (5 per cent lodging), while many of the varieties tested lodged to the extent of 50 or 75 per cent. Because of its high rating in straw resistance and its high yield, Wisconsin Wonder is now recommended for central Wisconsin.

The rate of seeding also was found to exert a considerable influence on lodging, the lighter seeding showing the least lodging, and, of course, a considerably smaller yield.

TABLE II.—YIELDS AND PERCENTAGE OF LODGING WITH PED. NO. 1 (Wisconsin Wonder) OATS

Rate sown pecks per acre	Lodging percentage	Date of ripening	Yield per acre bushels
4	None	August 6	45.5
8	10%	August 5	55.5
12	10%	August 5	61.3
16	30%	August 2	67.8

These results indicate that 8 to 10 pecks per acre is the right seeding for Wisconsin Wonder oats.

Experiments with mineral fertilizers to control lodging showed no satisfactory results.

Wheats for Wisconsin

Spring Wheat.—The experimental work conducted with spring wheat has been centered principally around the production of a variety of high rust resistance by E. J. Delwiche (Agronomy). Mr. Delwiche, after many thousands of selections from hybrid and mixed breeds

since this work began in 1909, has one strain, the M. 1611 (Early Java), which has consistently shown a marked resistance to stem rust, not only in his hands, but in tests made with farmers in upper Wisconsin and Michigan. One farmer at Wausau reported a yeield of 28 bushels per acre in 1921 and 25 bushels in 1922. This wheat is also of high gluten content (16.6 per cent in 1921), and work with it will be continued. About 1,000 bushels of this seed will be available for 1923 planting.

Winter Wheat.—Winter wheats are so much better yielders in upper Wisconsin that they are favored by most farmers. At Ashland this year Ped. No. 408 (Bacska) gave an average yield of 41.9 bushels per acre. Two other varieties (Ped. No. 2 and Ped. 11825) were close rivals with 40 bushels per acre. For six years winter wheats have produced an average of 1,938 pounds per acre, while the best oats only made 1,857 pounds per acre. Either as feed or grain for market, winter wheat is decidedly superior to oats for the Superior red clay belt, says Mr. Delwiche. At Marshfield, Bacska again led with a yield of 42.9 bushels per acre or over 30 bushels more per acre than the best spring wheat. Winter wheats, however, are lower in gluten and therefore less desirable from the miller's standpoint. Efforts will be continued to see if harder and higher gluten strains can be bred. Some selections from 1920 and 1921 hybrids show a decidedly high percentage of hard berries.

Producing Barley Seed Free From Stripe Disease

BECAUSE of the prevalence of stripe disease in the barley fields of Wisconsin, A. G. Johnson *(Plant Pathology) and E. D. Holden (Agronomy) for several years have been experimenting to obtain barley seed free from the barley stripe organism, *Helminthosporium gramineum*.

Several plots were tested with formaldehyde solution in 1921 in order to remove the disease, and later by a process of roguing out infected plants apparently disease-free seed was obtained. This was planted in 1922, and though frequent inspections were made, no striped plants were discovered.

From this work, the experimenters have concluded that stripe-free barley can be obtained from infected stock if the infected plants are not allowed to mature to the point where discharging lesions occur. Entire removal of infection was accomplished by seed treatment with formaldehyde solution combined with planting at a period which was naturally unfavorable to the development of the disease within the plants themselves. If the disease is one that can be entirely removed, it will not appear again until infection occurs from an outside source.

* In cooperation with United States Department of Agriculture.

Planting Distance of Sunflowers for Silage

CONTINUED work with sunflowers for silage purposes by E. D. Holden (Agronomy) has shown that the yields are fairly uniform regardless of the planting distance as long as it remains between 6 and 20 inches. Work during the past year has shown, however, the ratio of the amounts of stalks to leaves in the silage increases as the distance between the plants in the row becomes less. When the plants are as close together as 6 inches, there is a pronounced drying up of the lower leaves long before cutting, which results in a considerable loss. During the past year it was found that planting sunflowers 8 to 12 inches apart in the row will produce the most satisfactory results, and the Department of Agronomy is now recommending that rate because it overcomes the loss of leaves experienced when planting is too close. Though the relative proportion of leaves in the silage increases as the planting spaces increase up to 12 inches, no further gains are obtained by spacing the plants beyond that distance.

Rutabagas Outyield Mangels in Northern Wisconsin

THE RESULTS of a comparative study of the yields of rutabagas and mangels conducted at the various branch stations during the year confirm the findings of former years. In each case the rutabagas outyielded the mangels, and their cost of production was less both per ton and per acre. A very fine type of rutabaga is being developed at the Ashland Station, which seems especially well adapted to the clay and silt loams of central and northern Wisconsin. This seed will probably be available for distribution next year.

RUTABAGAS AND MANGELS COMPARED—ASHLAND, 1922

Variety	Yield per acre	Cost per acre	Cost per ton
Rutabagas (Monarch)	16.12 tons	$38.86	$2.41
Mangels (Sludstrup)	9.3 "	44.78	4.82

Kudzu Not Successful in Wisconsin

FURTHER experiments were conducted during the year with Kudzu, a viny leguminous forage plant introduced from Japan, that has been much advertised. The observations made at this Station during the past year have revealed no characteristics which warrant its use by Wisconsin farmers. While a dense growth of vines was produced by fall, the winter of 1921-1922 completely killed the stand, although red clover growing beside it was uninjured.

New Varieties of Peas for Wisconsin

FOR A NUMBER of years E. J. Delwiche (Agronomy) has been breeding canning peas at the Ashland Station until now we have the largest collection of pedigreed strains known. By hybridization and selection several excellent varieties have been developed, and there remains now the matter of fixing these best types and studying their relation to disease before dissemination of the varieties can be made.

Some new early Alaskan type strains known as Hustler, Alcross, and Double Alaska have been found to be about a week earlier than the earliest types of Alaskan peas so far tested. Of the new Badger and Horal varieties, considerable seed is also available for next spring's planting, and at that time a rather wide dissemination for these varieties is planned.

Continued experimental work at the Marshfield Station has also shown the desirability of long rotations (six years) to reduce the likelihood of disease. The value of inoculation was again tested, and the results were definitely in favor of the use of culture. (19.7 bushels per acre no inoculation; 23.3 bushels, inoculated.)

The adaptability of the stronger clay and silt soils of upper Wisconsin to pea culture has now been thoroughly demonstrated. Commercial interests have been encouraged to develop the canning industry in the Lake Superior region. The pea cannery at Marengo in Ashland County has been in successful operation for the past three years. The cooler climatic conditions that prevail in this section make it possible to extend the factory run considerably longer than in the southern part of the state.

The obvious advantage of a cash crop that will bring from $50 to $90 per acre as well as securing pea vine hay which is so highly prized makes this industry very promising for these new northern sections

Improvement of Sweet Corn for Canning Purposes

DURING THE PAST three years Mr. Holden has been engaged in breeding sweet corn for canning purposes. The work has been largely carried on in connection with fields of different canning companies, most of it being done at Columbus. The primary purpose of these experiments was to determine the merits of the different corns used by Wisconsin canners and to obtain data as to the yields of the different strains and of the amount and value of the fodder that remains for feeding purposes after the corn has been husked.

Some very satisfactory progress has been made up to the present time, and it appears probable that as a result of this work higher yielding strains of corn will be available for use by Wisconsin canners. Two strains of the Early Evergreen are especially promising, and several other varieties have shown outstanding vigor and yields. Sufficient seed is now available to give these strains more extended field trials in 1923.

Purebred Grains an Educational Factor

AGRONOMIC research has sought everywhere to lengthen the Wisconsin crop list, and by breeding and selection most of our present strains of field crops have been produced. In many cases the varieties now grown have been so improved that they resemble but slightly those from which they were originally obtained.

In recent years the studies of grains and crops have entered to an increasing degree into educational work. Junior departments have been added to state shows and to the International as well, and competition is keen among boys and girls in high schools and even in the grades.

At the 1922 State Grain Show held at Green Bay, the exhibits and judging contests of the boys and girls made one of the most interesting features of the entire display. Here, in a show sponsored by

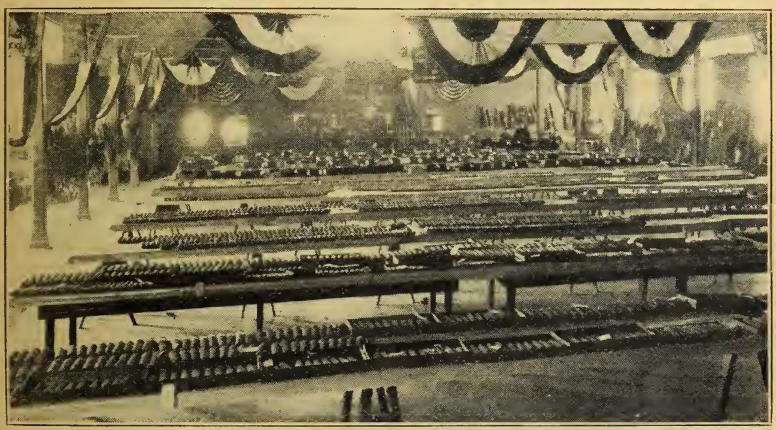


FIG. 23.—NEARLY 1000 SAMPLES WERE EXHIBITED AT WISCONSIN'S 1922 GRAIN SHOW

The state purebred grain exhibit at Green Bay was one of the largest on record. The junior exhibits comprised one of the strong features of the show—the young folks often compete successfully even with experienced seed growers.

the purebred seed growers of the state, where the high points of the production of quality grains were represented—where the best samples of our best varieties grown by our leading growers were assembled —the young folks held their own.

With the remarkable junior showing made at the Green Bay Grain Exhibit, which was one of the best of its kind in many years, it is apparent that our purebred grains are playing an important part in our educational system and that in time these efforts must become a distinct factor in our agricultural development.

Recent Developments in the Hemp Industry

THOUGH THE economic situation in the hemp industry has shown no improvement during the last year, research work in this field has been continued by A. H. Wright (Agronomy). Efforts were largely concentrated on the development of new uses for hemp fiber in order to stimulate the market. A certain amount of trade has been established among cordage manufacturers, and a promising field has been found in rug manufacture. Already rugs are being made from hemp and designs outlined so that it is hoped hemp rugs will become a standard article of commerce. The foreign markets are now peculiarly inactive, the low rate of exchange making it most difficult for America to produce hemp at a figure that will meet Italian competition.

Wisconsin-Grown Hemp Seed.—In the past we have been dependent upon Kentucky for our seed. But, as a result of eight years of work and selection at the Experiment Station, a variety known as the

FIG. 24.—THE RESULT OF USING BOTH POTASH AND PHOSPHORUS FOR HEMP ON MARSH SOIL

When both phosphorus and potash were used on hemp on marsh soil at Union Grove, the increased growth was pronounced. The plot on the right received 400 pounds of potassium chloride an acre, while the plot on the left received 600 pounds of acid phosphate in addition to the 400 pounds of potassium chloride.

Ferramington has been developed to such a degree that it can be utilized for seed production in this state. During 1922 experimental fields of this variety were grown at Union Grove and Beaver Dam. These fields were grown for fiber in competition with fields planted with Kentucky seed, and it appears now that they are entirely satisfactory. The *Ferramington* variety matured fully two weeks earlier than did the fields of Kentucky seed. Though the height of the plants was a little less than that of the Kentucky varieties, they were sufficiently high to make very satisfactory straw. The present results indicate that the Ferramington variety is altogether satisfactory, and if future occasion requires it, Wisconsin can depend upon this variety for seed producton.

Fertilizing Hemp on Marsh Soil.—Some interesting results were obtained from fertilizer tests made with hemp on marsh soil at Union Grove which was drained three years ago. This is a non-acid marsh and considered typical of the marshes of that section of the state.

In these trials the plots fertilized with potash only showed no appreciable superiority over the unfertilized check plots; but the plots receiving phosphorus as well as potash showed great additional growth. The plants on the check plots and the potash plots averaged less than two feet in height, which means that the crop on such land was practically worthless for fiber purposes. On the other hand, the crops on the plots receiving potash and phosphorus and those receiving potash, phosphorus, and nitrogen reached a height of from 7 to 8.5 feet. Where nitrogen was added to the phosphorus and potash, only slight additional growth was obtained, also a somewhat later maturity and a coarser straw.

Recent Work in Weed Control

ONE OF THE HEAVIEST taxes to which the Wisconsin farmer is subjected is that which is imposed upon him by weeds. Very often the farmer's most valuable acres are most infested and the land which is naturally suited to produce abundantly may become the least productive on the farm. The great number of pests with which the farmer must contend makes it necessary that the best methods available be applied in combating the invaders that have already established themselves in the fields as well as in keeping down those which have not yet had the opportunity to spread.

Austrian Field Cress.—Several years ago a plant, member of the mustard family, Austrian Field Cress (Radicula Palustris), an alien enemy of European origin, appeared in one of the fields of the University Farm. Methods were immediately used to exterminate the invader, but recently the plant again appeared in several areas. After several unsuccessful attempts had been made to rid the field of this infestation by means of tar paper and intensive cultivation of the smaller

patches in which it appeared, it was decided to summer fallow the entire field in order to insure the complete eradication of the pest. This treatment seems to have been very effective, and apparently the weed has been eradicated.

The extreme persistence and vitality of the cress plants make drastic measures for their destruction necessary. The vitality of the roots is amazing. In October 1919 a piece of root six inches long was put into a quart jar of water in the laboratory. It still bore green leaves in October 1921, having lived in the water for two years. The roots in the soil seem to possess an even greater degree of vitality, and sometimes new plants appear where none had been for two years.

Canada Thistles.—Areas of Canada thistles again appearing on a field, from which this weed had been eradicated some years ago, were treated by fall plowing followed by a year of cultivation, in which the field was plowed twice and cultivated four times during the summer. This plan of attack seems to be a successful one, inasmuch as after the summer fallow the eradication of the thistle is apparently assured.

Quack Grass.—The lower portion in one of the fields of the University Farm became so badly infested with quack grass that the affected area covered approximately 10 acres. The worst infestation seemed to appear in a portion of the field which was low and flat. To overcome this weed encroachment, the entire field was planted to Murdock corn, and, after the crop was harvested in 1921, it was fall plowed. In the spring of 1922 the infested area was dug up with a deep-digging cultivator, using tractor power, and then followed by three cultivations with a spring tooth harrow during the spring and summer of 1922. Very little quack grass could be seen by the last week of June, and on June 28 and 29 the field was seeded to Sudan grass at the rate of 25 pounds per acre. The crop was very heavy when grown to maturity and cut for seed, and this heavy smother crop seems to have successfully eradicated the quack grass infestation.

White Campion.—A bad infestation of White Campion (Lychnis alba) has appeared in one of the fields on the Hill farm. This plant is a biennial, and its seeds precede in ripening those of many cultivated crops, and when buried in the soil are very long-lived. In many sections of the state this weed is proving itself extremely troublesome in grass lands. The method of attack employed against this pest is the gathering and burning of all the vegetation on the ground, followed by cultivated crops, such as corn and potatoes, which is apparently eliminating this biennial plant.

Wildfire Disease in Wisconsin Tobacco

THE DISEASE of tobacco known as wildfire, which has caused large losses to tobacco growers in other states, made its appearance in Dane county early in 1922; and it is important that growers use all practical precautions to prevent its spread. So far as is known, the first serious outbreak of wildfire occurred in North Carolina in 1917, from where it spread rapidly to other tobacco sections causing severe losses.

In the Dane county outbreak the infected area has been relatively small. The first diseased plants from seed beds were brought to the Experiment Station on June 14, 1922, from the town of Deerfield. Subsequently it spread over most of the seed beds, from which about 12 acres of tobacco were transplanted. Shortly after this, another case was reported from the town of Burke. A detailed survey showed

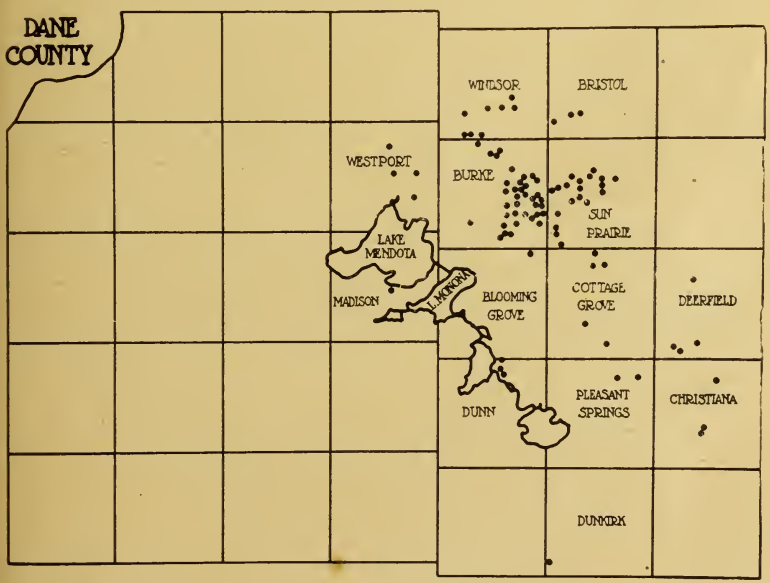


FIG. 25.—WHERE WILDFIRE APPEARED IN WISCONSIN

The tobacco wildfire outbreak in 1922 was confined to a small area in Dane county. With careful control measures it may be possible to prevent its further spread.

that the infection existed on about 90 farms, all of which were located in eastern Dane county, and arrangements were made with the State Department of Agriculture to apply measures of checking the disease.

Wildfire Starts in Plant Beds.—In practically every case field infection was traced to the seed bed, the disease attacking plants at

almost any stage of their growth. The typical symptoms are round bleached or yellowish areas on the leaves sometimes as large as a dime, in the center of which is a dried area often only the size of a pin point but varying up to as much as one-half inch and often with a distinct yellow border. These spots, when numerous, run together and cause the whole leaf to collapse and dry up. In some of the seed beds observed, the disease had practically destroyed all of the leaves on the plants. "Bud infection," in which the young leaves surrounding the bud turned to a light yellow color without any spots being present, seemed to be common in Wisconsin though not generally found in other districts.

For identification two facts should be noted: (1) Wildfire spots sometimes occur without any bleached area surrounding them and so may easily be mistaken for ordinary rust. (2) At least one kind of rust, the true old-fashioned rust of Wisconsin may resemble wildfire. In the laboratory it is easy to determine all cases of true wildfire by the use of special methods.

By reason of their position, longer exposure to infection, and higher susceptibility, the lower leaves of the plant are most likely to show infection, though the disease seems to attack with vigor any of the leaves of the plant and even the suckers and seed pods. Cigar binder and wrapper tobaccos may be rendered worthless for such purposes by comparatively few infections per leaf, and heavily infested leaves are ordinarily not worth harvesting.

The Cause of Wildfire.—Wildfire is caused by an organism known as *Bacterium tobacum*. The germ can be readily isolated and grown in pure cultures. Infection of fresh plants can be easily produced by inoculation.

Comparison With Other Rusts of Tobacco.—Ordinary tobacco rust is quite similar to wildfire in many respects, but it is due to a different bacterium and is much less serious and rare in its attacks. Its spots are ordinarily brown and show less of the yellow band around the center of infection. Rust occurs rarely, usually only in small parts of the field, and it does not spread so rapidly as wildfire.

Spread and Control of the Disease.—Once infection occurs in the spring, the disease is readily spread. In addition to being carried through the air under certain conditions, men, animals, tools, and other equipment may transmit it. It is most easily spread when the tobacco is wet, and at such times it is well to stay out of the field, One of the easiest means of spreading the disease from farm to farm is by the transfer of infected plants for transplanting. During driving rain storms, a general spread in the direction of the wind takes place, and a few infected plants in the field may cause a general infection to occur later.

To control the disease on farms where it has once occurred, James Johnson (Horticulture) made the following recommendations: Prevent seed bed infection by locating seed beds at a considerable distance from old tobacco beds, fields, or tobacco sheds; old plant bed

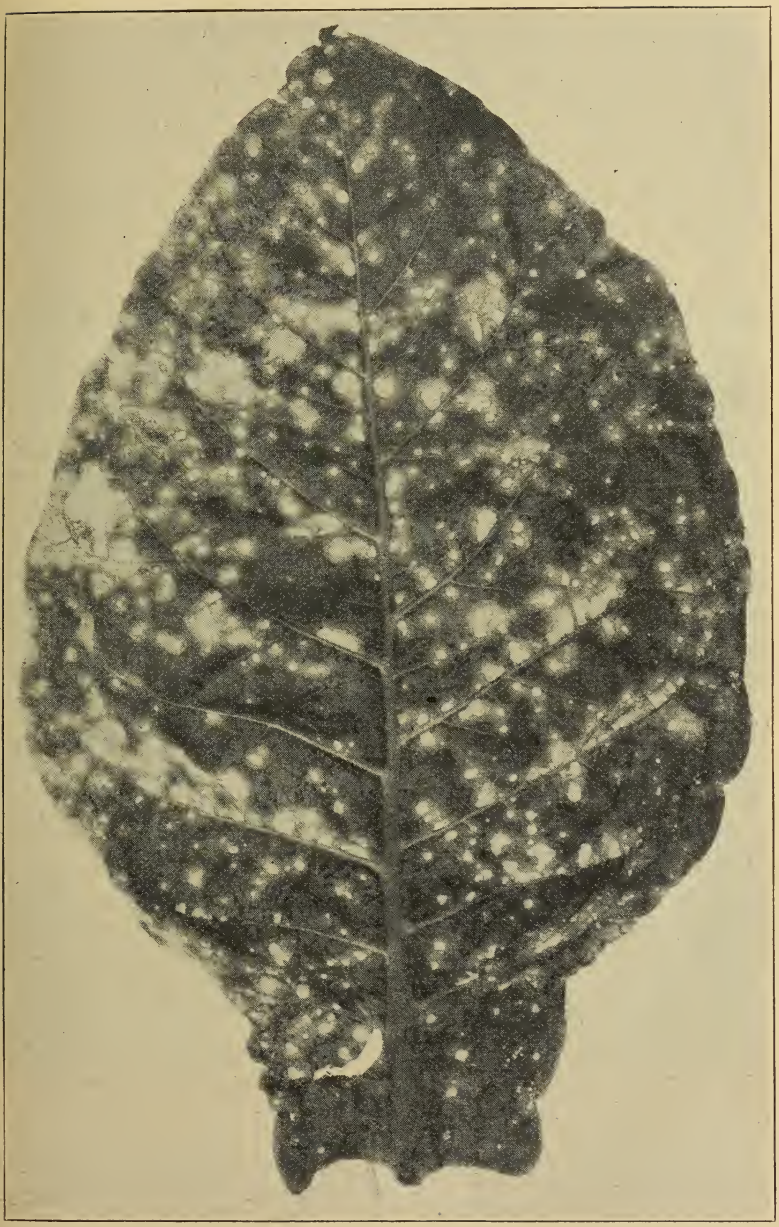


FIG. 26.—WILDFIRE SPOTS PRODUCE HOLES IN THE LEAF

Tobacco leaves heavily infested with wildfire disease are ordinarily not worth harvesting, and when the infection is general, serious losses are caused by it.

boards can be disinfected by sprinkling or painting with a solution of 1 part of formalin to 25 parts of water, and old covers by boiling for one hour. The tobacco seed should be disinfected unless it is known to come from districts where wildfire has not occurred.

Where wildfire infection is found in seed beds, it should be destroyed at once by drenching with formalin (1 part to 25 parts of water) and covering with some material to hold the fumes or by cutting the plants, sprinkling the area with kerosene and burning over. When weeding and pulling plants, the disease is frequently spread throughout the bed from such areas unless destroyed. If no

FIG. 27.—GOOD RESULTS FROM CLOVER ROTATED WITH TOBACCO

These adjacent plots show the benefits of clover in rotation with tobacco in comparison with no rotation. The experiment was planned to determine how much root-rot might be carried over from year to year by clover.

urther signs of the disease are noticed, it is fairly safe to use the remaining plants from such a bed, but it is best not to use those within several feet of the infected areas. To be entirely safe, plants from infected beds should not be used at all.

Rotation of Crops Pays With Tobacco

DETERMINING the best crop rotation for tobacco is a complex problem on account of the large number of factors involved. While it is quite generally regarded as good practice to rotate tobacco with corn, grain, and clover, or alfalfa in Wisconsin, very often poor crops are produced in spite of such a rotation under apparently ideal conditions of growth. In some cases low soil fertility, poor preparation of soil, and other factors are probably the primary cause of the results, but in others the ordinary black rot retains a foot hold in the soil over a period of years, and the ordinary rotation is not sufficient to eliminate it from the soil.

FIG. 28.—IT PAYS TO GIVE TOBACCO LAND A REST

Resting the land from tobacco dates from early colonial times, but only in the last few years have the most important reasons for so doing become evident; i. e., root diseases. A four-year rest helps but a longer one is better.

The Experiment Station data, however, show that rotation is highly beneficial in reducing the extent of disease damage. Where trouble has been experienced in the growing of tobacco in a regular rotation,

it is sometimes found that another root rot than the ordinary black root rot is concerned. This disease has been called brown root rot and is now being studied. Experiments have shown, however, that the black root rot organisms can persist in the ground at least six years even in the absence of the tobacco plant as a host, but during this time it is gradually reduced so that even a four-year period of rest from tobacco helps very materially in the growing of the crop. In badly infested fields it is probable that even better crops of tobacco could be obtained if such land were not planted to tobacco for as long a period as six years.

Potato Mosaic Influenced by Temperature

POTATO MOSAIC is one of the most serious potato diseases in Wisconsin, particularly in the production of certified seed stock of Triumphs. Fields which apparently are relatively free from the disease often yield seed potatoes which, when grown, produce a high percentage of mosaic for reasons not fully understood. Any information bearing on the cause of the "masking" of mosaic symptoms is, therefore, of interest. Following the clue obtained with tobacco mosaic where it was shown by growing the plants under carefully controlled temperature conditions that relatively high temperatures were most favorable for the disease, similar work was undertaken with the potato mosaic by James Johnson (Horticulture).

In the case of the potato disease it was found, however, that relatively low temperatures (57° to 65°F.) were most favorable for the

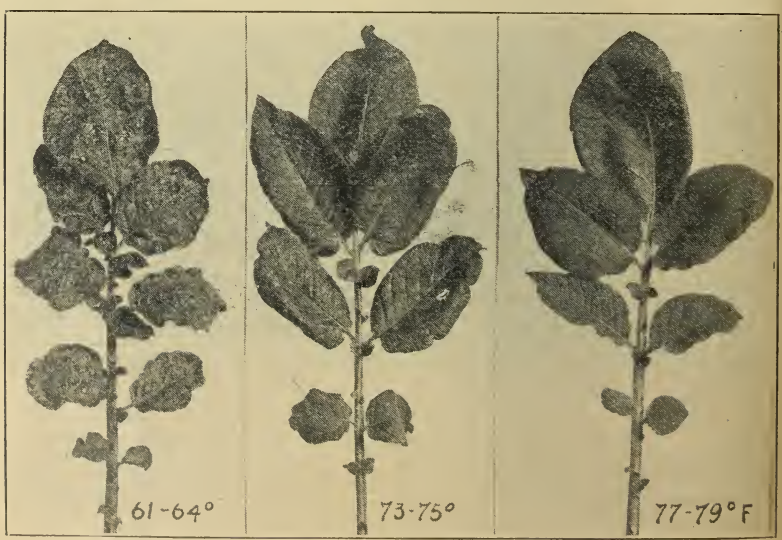


FIG. 29.—TEMPERATURE IS A FACTOR IN THE MOSAIC DISEASE

Periods of relatively cool weather are most favorable to the development of the mosaic disease in potatoes.

development of the symptoms of mosaic, and that at temperatures above 77°F. the symptoms of the disease may be made to disappear rapidly. Under field conditions then, mosaic is likely to show up most abundantly early in the season or after cool periods of a week or more later in the season if the plants are still young and in a rapidly growing condition. Conversely, fields showing a high percentage of mosaic at one season of the year may after a period of a week or more show far less. It is important that temperature conditions preceding inspection of fields for certification records should be considered. It is also fundamental that temperature relations should be more carefully taken into account in other lines of experimental work with the mosaic disease of potatoes and other plants as well.

Nitrogen Reserve in Apple Trees

CONTINUED studies in dwarf fruit trees grown in the green houses by R. H. Roberts (Horticulture) have shown that the condition of composition and vegetation greatly affects the pollen tube growth and fertilization of blossoms. It was noted that fertilization occurred in three or four days less time on very strongly vegetative trees than on poorly vegetative trees. The difference was apparently due to the amount of nitrogen reserve in the trees. Strong growth is usually made by trees having a large available supply of nitrogen either in the food supply or in the reserve stored up in the tissue.

The analyses of these reserves so far conducted under the direction of W. E. Tottingham (Agricultural Chemistry) have not been carried far enough to show conclusively in what form the nitrogen storage occurs.

Studies in Apple Scab Control

THIS SEASON has been favorable for the development of apple scab. In studies at Madison and Sturgeon Bay, G. W. Keitt and L. K. Jones (Plant Pathology) continued the spraying experiments of the previous years and, in addition, extended them to the effect of adding adhesives, such as gelatin, glue, and calcium caseinate to lime-sulphur 1-40, and also calcium caseinate to bordeaux mixture 4-4-50.

The most satisfactory spray program of the season consisted of lime-sulphur 1-40, (with powdered arsenate of lead, 1 pound per 50 gallons) applied on the following dates: (1) May 12-13 ("pre-pink"), (2) May 18-20 ("pink"), (3) May 29-June 1 ("calyx"), (4) July 8-14, and (5) August 5-11. In most tests the results from dry lime-sulphur 4-50 were similar to that obtained with liquid lime-sulphur 1-40. Bordeaux mixture 4-4-50 controlled the disease satisfactorily, but as in previous seasons it russeted the fruit to an extent that made its use inadvisable. The lime-sulphur program in which glue and gelatin, respectively, were used as adhesives gave less satisfactory control of

the disease than did the program of lime-sulphur without an adhesive. On the other hand lime-sulphur and bordeaux mixture, respectively, with the addition of calcium caseinate gave slightly better results

FIG. 30.—POWER OUTFIT USED IN SPRAYING EXPERIMENTS

This tractor-drawn spraying outfit is representative of a type now widely used in the large orchards of Door county.

than did these sprays without the addition of an adhesive. To determine the commercial value of this process, further trials will be required.

Tests were also made to determine the advisability of substituting dust treatments for certain liquid applications. The results obtained in this work were variable, apparently depending very much upon the relation of the time of application to meteorological conditions. In some cases very good control of the scab disease was obtained, while in others it was very inadequate. Three applications of lime-sulphur followed by two of dust gave essentially as good control of the disease as did the five-spray program of lime-sulphur.

Cherry Leaf Spot Investigations

FROM YEAR to year new methods have been tried out to protect the cherry crop from the ravages of the cherry leaf spot disease, and various control programs were tested during the past season at Sturgeon Bay by Mr. Keitt and Mr. Jones.

As in former years, bordeaux mixture 3-3-50 proved to be the most satisfactory spray, giving excellent control of the disease when applied (1) just after the petals fell, (2) two weeks later, and (3)

just after harvest. Similar programs of bordeaux mixture 2-2-50 lime-sulphur 1-40 and dry lime-sulphur 4-50 failed to control the disease with full satisfaction. Gelatin (.25 pound to 50 gallons), glue (0.5 pound to 50 gallons), and calcium caseinate (0.5 pound to 50 gallons) added as adhesives to bordeaux mixture 3-3-50 and lime-sulphur 1-40, respectively, failed to increase materially the effciency of these sprays. Dust applications as in former years failed to control the disease satisfactorily but gave sufficient promise to warrant further trials.

Relation of Plant Diseases to Temperature and Moisture

WHEAT AND CORN seedlings become susceptible to the wheat scab parasite only under unfavorable environmental conditions, according to greenhouse and field experiments carried on during the past three years.* These experiments conducted by J. G. Dickson (Plant Pathology) have shown that the two host plants respond in almost opposite manner to soil temperature. Wheat blights in a comparatively warm soil; that is, at soil temperatures above 52°F. while corn blights in a cool soil; that is, at a temperature usually below 64°F. The response to soil moisture is the same for both plants, wheat and corn seedlings alike being blighted by the wheat scab organism when grown in dry soils regardless of the soil temperature.

The results of the work obtained so far indicate that there are certain fundamental differences in the composition of the plants grown under different moisture and temperature conditions and that these differences in composition apparently explain the predisposition of the seedling to the blight disease.

Wheat seedlings grown at a low soil temperature have three distinct characteristics: (1) they are high in available carbohydrates; (2) low in available nitrogen; and (3) large amounts of available sugar are rapidly converted into cellulose in the tissues, which makes for thickened cell walls and considerable resistance to the wheat scab organism. When the seedling is grown under conditions of high soil temperature, the reverse is true: (1) there are present little or no available carbohydrates; (2) the seedlings are high in nitrogen in the form of readily available protein; (3) no thickening of the cell walls by reserve material occurs; and (4) at the high soil temperatures, therefore, the plant having no thickened cellulose deposition offers no resistance to the fungus, and the presence of an abundant supply of protein material results in a rapid development when once the parasite obtains a foothold.

The corn seedlings grown at a high soil temperature are comparable to wheat seedlings grown at low soil temperatures. They are high in available carbohydrates and low in available nitrogen, and some of the carbohydrate materials are laid down as cellulose. On the contrary, corn seedlings grown at low soil temperatures have

* Cooperating with the United States Department of Agriculture.

little available sugar or carbohydrate material and a plentiful supply of available nitrogenous material, which makes them, like the wheat seedlings grown at high soil temperatures, very susceptible to the fungous attack, and blighting results.

These experiments, therefore, indicate that the disease resistance and predisposition to disease in this case at least may be largely dependent upon the environmental conditions under which the plant is grown and the resulting difference in the chemical composition of the host tissues.

Disease Resistance in the Onion

CONTINUED investigations have been made to determine the possible relation of the coloring matter (pigment), volatile oils, or associated substances in the onion to the resistance of the plant to the invasion of the smudge fungus (*Colletotrichum circinans*). The former work of Dr. J. C. Walker, now with the United States Department of Agriculture, showed that disease resistance was closely associated with scale pigments and also influenced by the presence of the volatile onion oils.

In the recent work an attempt was made to determine more definitely the composition of the onion pigment and to isolate and identify, if possible, the substance responsible for the resistance to the smudge fungus. From the chemical analysis the onion pigments appear to contain: (1) a yellow non-glucoside, (2) one or more yellow glucosides, (3) a red non-glucoside, and (4) one or more red glucosides. A yellow glucoside or a mixture of glucosides has been crystallized from both the red and yellow onions, but so far has not been entirely purified. In the case of the yellow onions this mixture was found to be toxic to the fungus. These results are opening up an interesting field in explaining why the colored onions are immune to the smudge disease while white onions are not.

Cucumber Mosaic Investigations

INVESTIGATIONS of cucumber mosaic have been continued through the year by Messrs. M. N. Walker and S. P. Doolittle*, and it has been shown that this disease is carried over winter on the pokeweed, *Phytolacca decandra*, as well as on the milkweed and wild cucumber. The disease has also been transmitted to the pigweed and to the cultivated ground cherry. This makes it much more difficult to control the disease by the eradication of the plants on which it lives over winter.

*In cooperation with United States Department of Agriculture; H. J. Heinz Company; and the National Pickle Packers' Association.

Development of Cabbage Resistant to Yellows

IN ORDER to meet the needs of those interested in the kraut industry as well as in market gardening, special attention was given to the development of kraut varieties in field trials conducted at Racine during the past year by L. R. Jones and E. C. Tims (Plant Pathology). Several commercial strains of Copenhagen Market, Glory of Enkhuisen, and All Head Early were tried in addition to special strains of these varieties which were selected in former years. Of these selected strains, one of the All Head Early and one of the Glory of Enkhuisen appeared especially promising. They showed a fair degree of resistance combined with the essential earliness and conformity to type.

The Wisconsin All Seasons, which was distributed for commercial trials in former years, has proved of considerable importance to the kraut industry, due to the fact that kraut growers from the Mississippi Valley to the Atlantic Coast have been losing heavily from the yellows disease. The National Kraut Packers' Association was enabled through the coöperation with research workers of the United States Department of Agriculture and the Wisconsin College of Agriculture to grow for distribution several thousand pounds of this seed last year. Growers report uniformly satisfactory results both as to disease resistance and quality.

Crown-Gall Investigated

CROWN-GALL has been reported for a number of years as one of the limiting factors in the production of certain cane fruits in Wisconsin. The disease is caused by bacteria which gain entrance only through wounds and lead to development of more or less spherical galls which commonly occur at the crown. The disease has sometimes been called "plant cancer" because of the similarity in appearance and, to a certain extent, in structure and behavior to animal cancer. It is world-wide in its distribution, and it affects a very large number of host plants, but is especially common among the orchard trees and small fruits. In fact there are few plantings of raspberries and small apple trees in Wisconsin where crown-gall is not present, and the losses from this have, in some cases, been reported to be as high as 60 per cent.

A. J. Riker (Plant Pathology) has been studying the crown-gall disease with special reference to the relations of the organism to its host plants. Inoculation experiments on tomato have shown that wounds are necessary for infection. When needle punctures were made for inoculations, liquid was released which flowed immediately into the intercellular spaces causing water-soaked areas about the wounds. As the galls developed they were found to coincide closely in outline with these water-soaked regions. Expressed tomato sap was found to exert a positive attraction on the bacteria. They migrated through water-soaked tissue and produced galls at points

FIG. 31.—CROWN GALL IN THE SUNFLOWER

This case of crown gall or "plant cancer" was produced in the growing end of a sunflower stalk by inoculation.

removed from the site of inoculation. The bacteria observed in every case were located between the cells. They caused neighboring host cells to enlarge and divide, producing "secondary galls" and "tumor strands" as a result of the inoculation.

Sprays for Anthracnose in Black Raspberries

EXPERIMENTS for the control of raspberry anthracnose have been continued through the year by L. K. Jones (Plant Pathology) following in general the plans of the two previous seasons; and a more extensive comparison of the effectiveness of bordeaux mixture and lime-sulphur in combination and with various adhesives has been made. The results in general confirmed those of the two previous seasons. Two applications of lime-sulphur alone controlled the disease for commercial purposes. The best results, however, were obtained by the use of two applications of lime-sulphur with glue, gelatin, casein lime, or saponin as an adhesive. In general, bordeaux mixture alone or in combination with the various adhesives gave less satisfactory control than lime-sulphur. Two applications of bordeaux mixture alone or in combination with the above adhesive gave satisfactory control of the disease in a commercial way. A third application of bordeaux or lime-sulphur about a week after the blooming period was beneficial in reducing the amount of the disease, but this spray was accompanied by severe foliage injury.

How to Succeed in Wintering Bees

THE PROBLEM of wintering bees in Wisconsin is important because the average winter losses for the entire state are from 15 to 20 per cent and sometimes run as high as 30 per cent of all the colonies. Successful wintering with very little loss is possible if the proper storage is provided and proper temperature maintained. The colony must pass through the winter period in as inactive a condition as possible in order to reach the early spring brood rearing period and still be strong with young bees. Under winter conditions the bees form a more or less compact cluster for the preservation of heat which is produced by the muscular activity of the individual bees. If this activity is relatively great, it tends to shorten the life of the individuals and therefore lessen the strength of the colony as a whole. Thus, the question of maintaining a temperature that will not require undue losses of energy through excessive muscular activity becomes an important one.

The primary purpose was to study the relative value of different kinds of packing material used for wintering bees.* Three colonies were used; one placed in an ordinary ten-frame Langstroth hive in the bee cellar; another in the same kind of hive but in a double packing case, surrounded with 6 inches of packing and 12 inches above, was placed on the east side of the building; and a third in a double walled hive with one inch of packing on the sides and four inches of shavings on top. It was found that there is a more or less definite reaction in the colony of bees to changing temperatures. As the temperature outside becomes lower, the temperature within the cluster of bees begins to rise; and it has been shown that the

* These experiments were conducted by V. G. Milum and H. F. Wilson (Economic Entomology).

colony will keep a fairly constant temperature around the outside of the cluster ranging from 57° to 60°F. This temperature is maintained almost constantly regardless of how cold it may become. As the temperature without goes down, the bees develop by muscular activity a higher temperature within the cluster, and the mass also becomes more compact.

TABLE III.—REACTION OF COLONY TO TEMPERATURE

Outside temperature	*Temperature in outer portion of cluster	*Temperature in center of cluster
40° F.	57° to 60° F.	70° F.
30° F.	57° to 60° F.	80° F.
0° F.	57° to 60° F.	75° to 80° F.
—5° F.	57° to 60° F.	70° to 75° F.

These results show that, though the bees may be unable to keep on increasing the temperature of the inside sufficiently to resist the cold, the temperature on the outside of the cluster still remains at or near from 57° to 60° F. It appears certain that if the low temperature is maintained very long, the bees must become unable to resist it and eventually die.

The conclusion from these observations is that it is necessary for bees to use up a great deal more energy when packed out-of-doors than is the case when they are packed in the cellar; and that increased amounts of packing around the bees necessarily kept out of doors helps them in keeping the cluster temperature at 57° with less energy and consequently gives them a better opportunity to survive the winter.

Fighting American Foulbrood With Sodium Hypochlorite

FOR OVER twenty years beekeepers of Wisconsin have suffered heavy losses from a bacterial disease of the colonies known as American foulbrood. The disease attacks the larvae in the cells, gradually spreads to such a degree that the infected colonies usually die out completely at the end of the second season, or become so weak that they fail to live through the winter. Hundreds of empty hives are found in many parts of the state as the result of the ravages of this disease.

In an effort to find a satisfactory means of destroying spores of the organism, *Bacillus larvae*, which causes American foulbrood, experiments in the use of a specially prepared sodium hypochlorite were carried on during the past year by H. F. Wilson (Economic Entomology). The results show a solvent action on dead bees, pollen,

*These temperatures were determined by means of electric thermocouples.

cocoons, and other debris in the combs, but the compound does not injure the wax though concentrated solutions will dissolve a dead bee in a short time. Diluted solutions are found to be not at all harmful to the bees when added to their food.

Living as well as dead larvae in the cells were completely dissolved in 24 hours. Four combs so treated were placed in colonies of bees in June and remained free from the disease throughout the summer, although the bees continued to rear brood in them. Syrup to which a water solution of spores had been added did not carry the disease after being treated with a weak solution of the chemical. Three colonies fed a diluted solution of diseased honey so treated showed very satisfactory results, two of them remaining free from disease and the third, though developing it, was shown to be infected from an outside source.

From this work it appears that the specially prepared sodium hypochlorite destroys the spores of the *Bacillus larvae* wherever it comes into contact with them and that it is not poisonous and may be fed in syrup or honey to bees without apparent injury to them. For disinfecting hives and equipment the solution was found to be highly efficient.

It Pays to Spray for Potato Leafhopper

THAT THE raids of the potato leafhopper, which have caused considerable loss to the potato growers, can be successfully avoided by proper spraying was demonstrated during the past year. Bordeaux mixture used in one plot at Waupaca by C. L. Fluke* (Economic Entomology) increased the yield from 83.25 bushels per acre in an unsprayed area to 186.5 bushels in the sprayed plot. Four applications of the bordeaux mixture at 4-4-50 formula were made on the following dates: July 7, July 17, July 27, and August 5. When the comparison is made in U. S. Grade No. 1 potatoes, the differences are even more striking. Check plots yielded 49.5 bushels, and the plot

TABLE IV.—RESULTS OF USING SPRAYS ON POTATOES

Plots	No. applications	Yield in bushels per acre			Total yield per acre
		U. S. Grade 1	U. S. Grade 2	U. S. Grade 3	
Homemade bordeaux 4-4-50 plus arsenical	4 (3 nozzles to the row)	144	36	6.50	186.50
Commercial powder bordeaux plus arsenical	5 (2 nozzles to the row)	90	33	5.66	128.66
Arsenical only	4 (3 nozzles to the row)	49.5	29.25	4.25	83.25

*In cooperation with State Department of Agriculture.

which received the homemade bordeaux, produced 144 bushels per acre, nearly three times as much as the check plots.

An especially prepared spraying boom was used in this work, which was equipped with nozzles that thoroughly covered the underside of the leaves. The three nozzles used to each row were so arranged that one sprayed down and two upward, one on each side of the row. The leads to the lower nozzles were made with short rubber connections to prevent breakage in the striking of obstacles.

From 75 to 100 gallons of spray were applied per acre, and an effort was made to keep the spraying pressure at 200 pounds. Arsenical poisons were added to kill the potato beetle, and the check plots were also sprayed for beetle control.

The success of the "homemade bordeaux" is evident as it more than doubled the yield obtained where arsenical sprays alone were used and demonstrates clearly that it pays to control the potato leafhopper in Wisconsin.

Effect of Nicotine Dusts on Crop Insects

THAT DUSTING can be used effectively against certain insects has been known for 20 years, but the use of contact insecticides such as nicotine compounds is a more recent development. While the actual cost of dusting materials is somewhat greater than that of spray materials, the cost per acre is usually less. In addition the dusting process has the advantage of a wider range of

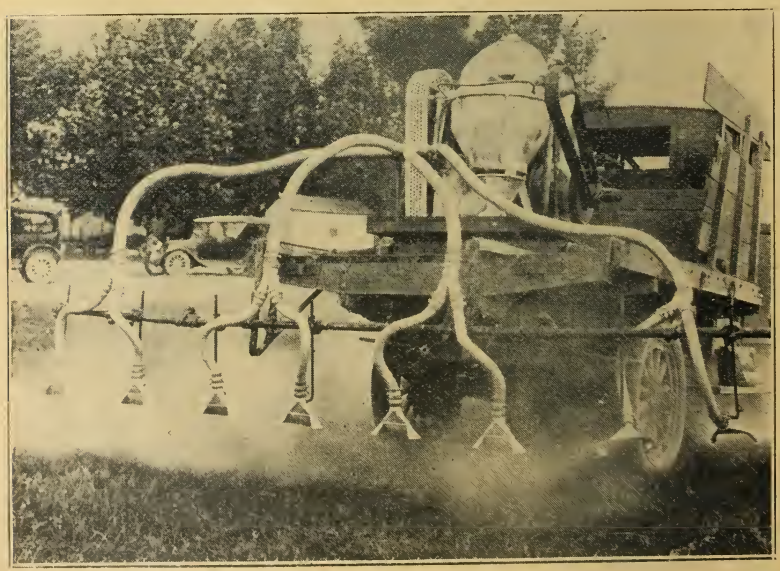


FIG. 32.—CONTROLLING PEA APHIS BY DUSTING

This is a Dosch power duster in action. The amount of dust leaving the nozzles can be adjusted to a very fine degree.

application inasmuch as moisture conditions do not affect the operation. It seems to work equally well whether the vines are wet or dry. Wind seems to be the only limiting factor. Work is in progress in nearly every state to perfect the process, and it appears probable that in time it will replace spraying to a very large extent.

As a continuation of last year's experiments, further data were collected on the effects of a new type of insecticide—nicotine sulphate in dust carriers by J. E. Dudley, Jr. (Economic Entomology).* Exhaustive tests were made against eggs, larvae, or adults of the fol-

FIG. 33.—PLANT LICE NEARLY DESTROYED THIS CROP

Rutabagas nearly dead from attack of plant lice are saved by applications of nicotine dusts.

lowing insects: squash bug, Colorado potato beetle, potato flea beetle, onion thrips, turnip aphis, melon aphis, and two species of cabbage worms.

The Squash Bug.—A number of careful tests were made against the squash bug in all stages, in which 100 colonies, averaging over 100 individuals in each, were treated, and it was shown that nymphs of the first, second, and third stages are readily killed by nicotine dusts containing from 4 per cent to 7 per cent nicotine sulphate; and that fourth and fifth stage nymphs and adults are quite resistant to these materials, seldom more than 30 per cent being killed; and that nicotine dusts have no effect upon the eggs. It was also found

*Cooperating with United States Department of Agriculture.

that, when colonies consisting largely of nymphs in the first three stages were dusted early in the season, it was quite possible to obtain from 95 per cent to 99 per cent control.

The Colorado Potato Beetle.—Potato beetle larvae in the first three stages are readily killed by nicotine sulphate combined with lime or copper sulphate-lime and containing from 5 to 10 per cent nicotine sulphate. All the young larvae were killed in three tests covering 75 hills of potatoes. When larvae in the fourth and fifth stages were dusted from 60 per cent to 80 per cent were killed. Potato beetle eggs are readily destroyed by nicotine dusts.

The Potato Flea Beetle.—Eight tests of two nicotine dust combinations containing from 4 to 7 per cent nicotine sulphate were conducted against flea beetle on potato plants in large cases. Of a total of 1,600 beetles so treated, all were killed.

The Onion Thrips.—In five tests with nicotine dusts varying in strength from 5 to 10 per cent nicotine sulphate against thousands of onion thrips in an onion field, results showed percentages of killing of from 87 to 90.

The Turnip Aphis.—A field of rutabagas nearly killed out from a severe infestation of the turnip aphis was treated with nicotine dusts containing 5 per cent nicotine sulphate. When hand dusters were used, from 90 to 95 per cent of the aphides were killed and, when the whole field was treated with a power duster, from 95 to 98 per cent of the aphides were killed.

The Melon Aphis.—Tests of nicotine dusts containing from 7 to 10 per cent nicotine sulphate on 175 hills of melons heavily infested with the melon aphis resulted in 90 per cent of the insects being killed by the 7 per cent dust, and 100 per cent by the 10 per cent dust.

The Cabbage Worms.—Cabbage worms infesting fields of cauliflower and rutabagas were treated with various combinations of nicotine dusts. The effect of the dusts appeared to be governed greatly by the temperature. With an average temperature of 90°F. from 64 to 75 per cent were destroyed. With an average temperature of 58°F. from 18 to 37 per cent were killed.

Controlling the Striped Cucumber Beetle

SATISFACTORY results in controlling the striped cucumber beetle were obtained during the past season in experiments by Mr. Dudley. Nicotine sulphate combined with hydrated lime, copper sulphate, and lime, unslaked lime, gypsum, and sulphur were used against the insect with good success.

A mixture of nicotine sulphate and hydrated lime containing 5 per cent nicotine sulphate was tested out five different times on cucumbers and squash under varying conditions of temperature, humidity, and wind. An average of 75 per cent of the beetles were killed. A

mixture of nicotine sulphate and hydrated lime containing 10 per cent of nicotine sulphate, tested six different times under extremes of temperature, humidity, and wind, killed on an average 91 per cent of the beetles, varying from 83 per cent to 98 per cent. The best results were obtained in the absence of wind under high humidity and high temperature.

A mixture of nicotine sulphate and copper sulphate-lime (uncombined bordeaux), containing 10 per cent nicotine sulphate, gave an average kill of 86 per cent. It was found that a rather inert car-

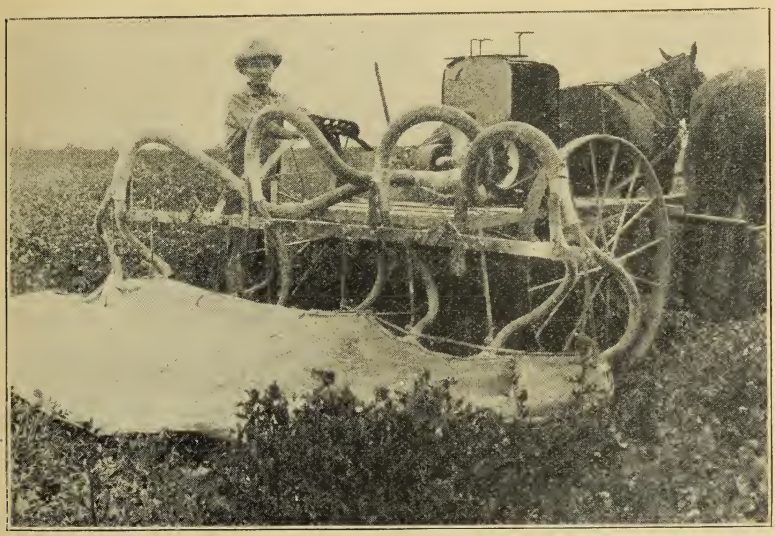


FIG. 34.—THE CANVAS TRAILER HELPS CONTROL PEA APHIS

A power duster showing the canvas trailer attached. This keeps the dust from drifting too soon.

rier of the nicotine sulphate, such as hydrated lime or gypsum, was preferable to an active carrier, such as unslaked lime, because much nicotine is lost by volatilization when it is mixed with an active substance.

It now appears that the striped cucumber beetle can be controlled by two or three thorough applications of dust containing 10 per cent nicotine sulphate (4 per cent actual nicotine). The first application should be made early in June or just as soon as beetles have commenced to attack the plants. A duster having an arrangement for expelling the dust with force is necessary for effective work.

Flight Experiments.—Continuing the work of last year tests were made with over 35,000 cucumber beetles in order to determine their length of flight. Results show that they had flown on an average about one-half mile each, so it seems probable that this insect seldom flies over that distance.

For several years the rather sudden disappearance of cucumber beetles in late July and early August has been noticed; and during the past season an effort was made to explain this condition. It was found that the overwintered beetles, which constitute the great majority at this time, die off rapidly in the latter part of July; and the first generation coming on at this time are few in number and they do not increase until well into the fall. A carefully controlled experiment has proved conclusively that there are two generations of beetles occurring in Wisconsin annually, and this year a partial third obtained.

Control of the Pea Aphis

WORK ON THE control of the pea aphis upon a commercial scale was begun the past season. A general survey was made of the growing of field peas and data collected on the infestation of the pea aphis, by Mr. Fluke and Mr. Dudley, and some tests were made with nicotine dusts to determine their value in this work. Results show that the pea aphis is one of the most resistant aphides to nicotine fumes. When power dusters were used, the percentage killed varied from 55 to 95, depending somewhat on the percentage of nicotine in the dust, the temperature, and the absence or

FIG. 35—THIS IS NOT A SMOKE SCREEN ON A BATTLEFIELD BUT A DUST SCREEN FOR CONTROLLING PLANT LICE.

In the foreground the lice had killed all the plants, and the ground was re-seeded. To the left, the plants were treated with hand dusters applying nicotine dust.

presence of wind. A large sheet of canvas or a trailer was dragged over the peas just behind the duster to keep the material from spreading and in this way much better results were obtained.

The problem in this work is to find the most economical material to be used, the least injurious method of application, and also the most opportune time of treatment as well as to determine whether

the treatment is necessary each season. Work on this subject will be continued in coöperation with the United States Department of Agriculture.

Sawdust Cheapens Grasshopper Poison

SAWDUST CAN BE substituted for bran in the formula for poison grasshopper bait, according to the tests made by Mr. Fluke this season. This change is effective when middlings are added as a coating to the prepared bait. The formula which was used successfully is as follows:

	Pounds
Sawdust (hardwood preferred)	25.0
White arsenic	1.25
Salt	1.25
Amyl acetate	12.0
Water (enough to moisten, about 3 or 4 quarts)	
Middlings	5.0

The sawdust, white arsenic, and salt are mixed dry; the amyl acetate is added to the water and then mixed with the dry ingredients. After these ingredients are well mixed, middlings are added and the whole is stirred.

There is no particular advantage in the use of this bait over that which contains bran, except that the cost of material is reduced about one-half.

Inasmuch as there are two different feeding times for the various species of hoppers, some of them feeding during the morning hours and others during the afternoon, the time of application of the bait plays an important part in its success. The bait loses its effectiveness quite rapidly; therefore it is necessary to apply it as near before the feeding hours as possible.

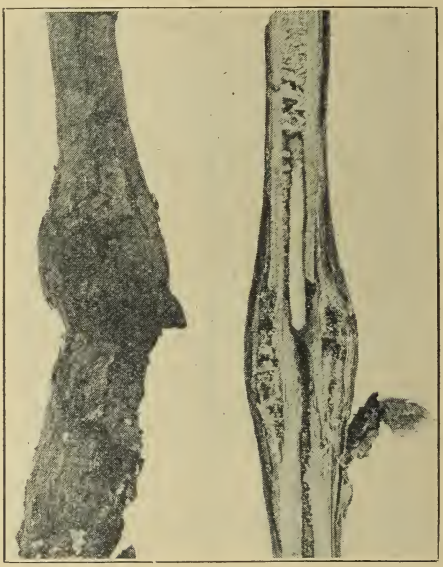
Red-Necked Cane Borer on Raspberries

THAT THE raspberry industry in Wisconsin has been greatly reduced because of the ravages of diseases and the raids of insects was shown in a survey made some years ago. One of the most troublesome insects in raspberry culture, the red-necked cane borer *(Agrilus ruficollis)*, has been studied during the past year by A. Weed, working under C. L. Fluke (Economic Entomology). The adult borer is a beetle about one-third inch in length, small, slender, and tapering slightly toward the end of the abdomen. The upper wings and head are blue-black in color, while the thorax is reddish or coppery; the brassy neck makes it very easily recognizable and also accounts for the name of the species.

From data collected in the vicinity of Madison, it appears that the insect emerges from the raspberry canes during the latter part of

May or early June through an almost circular opening cut into the cane by the newly developed insect.

The work of the larvae in the cane can be readily recognized in late fall or during the winter and spring by the swelling or galls



(A) (B)
FIG. 36.—THE RED-NECKED CANE BORER

(A) Basal swelling caused by the larva.
(B) Larva making its way up the cane above the first or upper gall.

found at intervals upon the cane, and usually two in number. The insect can be held in check by the exercising of care in pruning the cane fruit by cutting below the galls and then burning the cuttings to destroy the larvae.

Moldy Bread Outbreak Due to Infected Flour

A BAKING company at Eau Claire, after suffering considerable loss due to an outbreak of mold in bread in 1921 appealed to the College for help in solving the problem.

The bread showed mold development inside the loaf within one and one-half to two hours after removal from the oven. Often by the time the bread had reached the consumer, the mold had penetrated to the entire loaf. It is a common opinion that moldy bread is occasioned only through contamination of the loaf after baking. But in this case everything had been thoroughly cleaned; the bread was wrapped immediately after baking; and it was shown that the wrappers were not at fault since the bread developed mold whether it was wrapped or placed in a closed box.

W. C. Frazier (Agricultural Bacteriology), in studying the outbreak, found that the trouble came from the flour. Two brands of flour were being used, one of which was very high in mold content, showing as many as 11,000 mold spores per gram of flour. The trouble stopped immediately when the use of this infected flour was discontinued.

Bakers are commonly of the opinion that the temperature attained by the loaf of bread in the baking process is sufficient to destroy mold spores. The temperature, however, is slightly below 212°F.

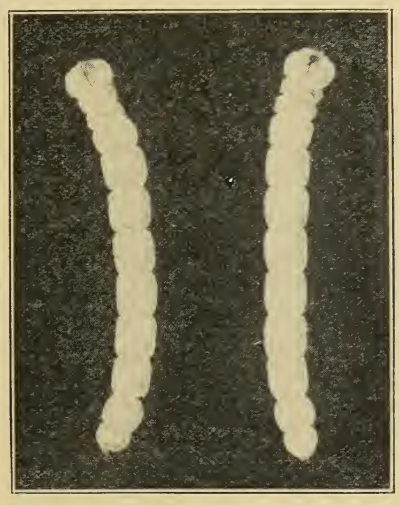


FIG. 37.—THE CANE BORER LARVAE

Full-grown larvae are white in color and semi-transparent (about 2½ times actual size).

Examination of the moldy loaves in the recent outbreak showed that the mold first began to develop in a crease in the loaf which is formed by the partitions between the series of pans. In it the dough warms up very quickly in the baking process and apparently dries out as is shown by the doughy appearance and the unchanged starch grains in that portion of the bread.

It appears that because of the reduced water content of the dough at this point, the mold spores in this area are able to withstand the heat. Since the trouble was noted only in the bread which was wrapped immediately after its removal from the pan, it seems that a contributing factor to mold development is the moisture which collects in these unbaked portions of the bread after baking because the wrapper does not permit it to escape. In the unwrapped loaves the mold spores present were unable to germinate because the moisture was taken up by the air, with no opportunity to collect in the unbaked areas.

Yeast Causes Sauerkraut Discoloration

DURING THE latter part of 1921 numerous complaints were made by the sauerkraut manufacturers of Wisconsin because their product became discolored after it was transferred from the large vats into the wooden casks. This discoloration took place after the kraut had "ripened." The trouble is entirely different from that which is commonly known as "pink sauerkraut."

W. H. Peterson (Agricultural Chemistry) and E. B. Fred (Bacteriology) devoted considerable time to the study of the kraut discoloration problem. After a detailed survey they found that the trouble is caused by a yeast-like organism which brings about a harmful fermentation. All affected krauts were high in alcohol and relatively low in lactic acid. The destruction of lactic acid is accompanied by an increase in alcohol and brings about a decided change in the taste and color of the kraut. This change renders it unsuitable for food and results in large losses to the manufacturers. Promising results were secured by a change of brine and the use of carbon dioxide, but to complete the work further experiments will be required.

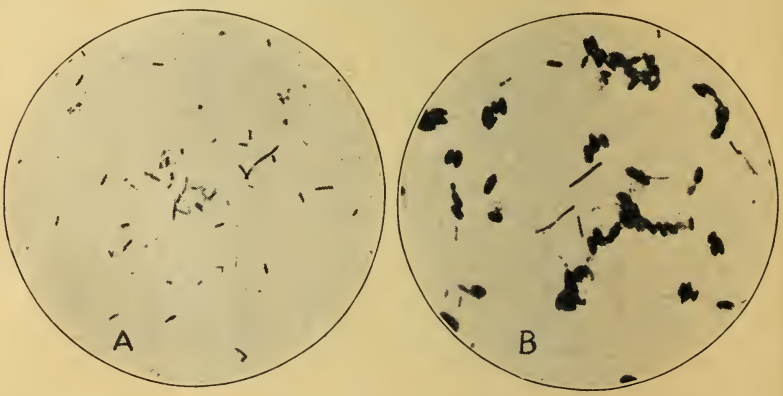


FIG. 38.—ORGANISMS WHICH DISCOLOR KRAUT

(A) Photomicrograph of juice from normal sauerkraut.
(B) Photomicrograph of juice from discolored sauerkraut.
Magnified about 950 diameters.

Grouping Legume Nodule Bacteria

BY ADOPTING a test that has long been used in medicine (the agglutination reaction), Mr. Fred and J. W. Stevens (Bacteriology) have found that the nodule-forming bacteria of legumes can be readily separated into their various strains. These groups, when thus separated, correspond to the groups found by means of inoculation experiments with plants. In addition this test also shows some new subdivision within the known groups of organisms.

The test is carried out as follows: 1 c. c. of a suspension of the bacteria is injected into a rabbit. This is repeated three times, doubling the dose each time. In this way the serum of the rabbit's blood becomes sensitized to the particular strain of bacteria.

When the clear serum is separated from the blood of the rabbit and to it is added a suspension of the same kind of bacteria with which the animal was inoculated, it is found that the bacterial cells collect in clusters (agglutinate) and settle to the bottom. With other strains of organisms no reaction is produced with the particular serum.

Forty-one strains of legume bacteria have been tested for this property, and it is found that they can be separated into a far greater number of divisions than is possible by the plant inoculation test. For instance, 14 strains of alfalfa and sweet clover bacteria fall into two definite groups. It is hoped that this subdividing of the larger group will enable a selection to be made of the most active nitrogen-fixing strains of nodule-forming bacteria. This new method offers quite a new point of attack to the problem of legume inoculation.

Experiments With Silage

LARGE losses are annually sustained by farmers from the decomposition of silage, both on top and along silo chutes. Various ways have been tried to eliminate these losses, and experimental work on this subject is still being done. Since there are already over 90,000 silos in the state, work on this subject is assuming considerable economic importance.

The Fink Silo Seal.—Because of the requests received for information concerning the value of the Fink Silo seal, a study was made of the losses which occurred on the top of a silo with the seal and on the top of one without the silo seal by Mr. Fred and Mr. Peterson. Though the results are not complete, they indicate that there is a decided loss of silage even when sealed by means of the special silo seal.

Loss in Dry Matter in Making of Silage.—By use of water-tight sacks, an attempt has been made to study the losses which occur in the making of corn tissue into silage. The results indicate that this loss is not so great as has been reported by former investigators. In general it was found that there was a decrease in dry matter of from 4 to 8 per cent, but further investigation will be made in order to obtain, if possible, a more definite figure.

Lime and Inoculation Affect Nitrogen Fixing Capacity of Legumes

THAT lime and inoculation influence the growth of legumes has been known for a long time, although there is no way of estimating very accurately the annual gain in nitrogen due to the activity of the root nodule bacteria.

Work this past year under greenhouse conditions by E. J. Graul (Soils) and Mr. Fred shows that this gain occurs in both non-acid and

acid soils. On strongly acid soils it is important to know whether it is necessary to neutralize all of the soil acidity in order to grow a profitable crop of a legume, such as alfalfa. Small applications of limestone usually produce a decidedly beneficial effect on the growth and nitrogen content of the plant, in fact, often more so than when very heavy applications of limestone are made.

A number of trials on several different types of soils have been made during the year with alfalfa and red clover. Analyses of the soil and seed were made at planting time, also of both the soil and the crop when harvested. The difference between the total nitrogen content of the soil and the seed at planting time and that of the crop and the soil at harvesting time was taken as the amount of nitrogen fixed from the air by the root nodule bacteria.

Alfalfa on Colby silt loam gave the following results:

	Nitrogen fixed per acre
Alfalfa unlimed	82.1 pounds
" —2.5 tons of limestone per acre	106.2 "
" —5.0 " " " " "	108.3 "
" —7.5 " " " " "	112.4 "
" —10.0 " " " " "	87.9 "
" —15.0 " " " " "	67.2 "

On Plainfield sand alfalfa fixed nitrogen as follows:

	Nitrogen fixed per acre
Alfalfa unlimed	104.9 pounds
" —1.25 tons of limestone per acre	107.8 "
" —2.5 " " " " "	69.9 "
" —5.0 " " " " "	45.8 "

Medium red clover on Plainfield sand showed the following results:

	Nitrogen fixed peracre
Clover unlimed	100.2 pounds
" —1.5 tons of limestone per acre	140.0 "
" —2.5 " " " " "	72.8 "
" —5.0 " " " " "	12.5 "

In all of the trials the seed was thoroughly inoculated. These results indicate that a partial neutralization of existing acidity of the soil is necessary to secure maximum production, and that a thorough inoculation of the legume helps the plant to overcome the unfavorable effects of soil acidity.

Plowing Under Green Brush

THAT large amounts of green wood tissue retard the growth of higher plants has been shown in a series of carefully controlled pot tests by Mr. Fred and A. C. Fiedler (Agricultural Engineering). Virgin soils from the cut-over district were used and finely divided wood, such as alder, poplar, willow, and birch, were added to the soil in which oats were planted. Apparently, the different woods have a decidedly varying effect upon the growth of cereal crops. Green alder and green poplar seems to be quite injurious to the oat plant, while green willow and green birch cause only a slight decrease in the growth. Plot investigations are being conducted to determine more definitely the toxic effect of green wood upon the growth of higher plants.

FIG. 39.—TURNED UNDER BRUSH AFFECTS THE PLANT GROWTH

This experiment shows that green wood, when mixed with the soil, may be toxic to plants. Apparently the effects of some woods are much more marked than others.

"Stinker" Swiss Cheese Increasing

"STINKER" CHEESE has increased to a great extent in the Swiss cheese industry during the last few years. Cheese so affected is darker in color and is characterized by a foul odor that often makes the product unsalable. Commonly the trouble is confined to small areas within the cheese, making it usually impossible to detect it from the outside.

Many explanations have been suggested as to the cause of this trouble, such as difficulty in curdling of the milk and the influence of feed, especially silage. Others believe that mechanical stirring devices which are somewhat widely used are the cause, but none of these explanations is based on any scientific study.

E. G. Hastings and W. C. Frazier (Agricultural Bacteriology) find on analysis that in many cases, as the odor increases, it is characterized by hydrogen sulphide (H_2S). Large numbers of butyric acid-forming bacteria are also found in the spoiled areas while very few of these organisms occur in the unaffected cheese. These bacteria grow in the presence of considerable amounts of acid such as are formed by the ordinary acid-forming organisms in Swiss cheese. The problem has only been opened up and needs more investigation, as it is a source of much loss in the Swiss cheese industry.

High Quality Milk Shut Out by Laboratory Tests

IN MAY 1922 the Experiment Station was consulted by certain Waukesha certified milk producers when their product was shut out of the Chicago market because it was alleged that haemolytic streptococci (blood-dissolving bacteria) were found in it. W. D. Frost

and Miss Freda Bachmann (Agricultural Bacteriology) examined about 500 samples of these milks and found that, in from 15 to 40 per cent of the milks of cows in three herds, organisms occurred that were often of the Beta type, (this type is generally assumed to be associated with streptococcus sore throat). Bacteria of this type are no doubt widely distributed, but little study has been made of their presence in milk except in times of epidemics. Similar organisms have been found in the milk of 15 per cent of the animals in the University herd. In no case, however, has there been any reason to suspect the safety of any of these milk supplies. This shows the laboratory methods employed need much more verification than now exists before being accepted as final in this regard. Certified milk producers are vitally interested in this problem as the present attitude of city health officials is to consider such organisms as potentially dangerous in a milk supply.

Trials With Tuberculosis Vaccine

FOR YEARS scientists have sought a way to reduce by means of a vaccine the ravages of tuberculosis. W. D. Frost (Agricultural Bacteriology) and assistants have made some progress by using tubercle bacilli, killed by means of ultra-violet light, as a vaccine, for which the name of *tubuvase* has been suggested. It was shown that the process of manufacture would kill the tubercle bacilli, rendering the method safe, also that the vaccine had considerable preventive properties.

Inasmuch as the proper dosage of tubuvase is not known, Mr. Frost proposes to continue the experiment by using much larger quantities of the vaccine. Recent experiments indicate that more than one hundred times the former maximum dose may be given with perfect safety.

When it is considered that from 25 to 30 per cent of the hogs killed in this state are tuberculous and that most other farm animals are more or less subject to it, any disease resistance which could be built up in the bodies of the little pigs by means of *tubuvase* would be of great economic importance to Wisconsin, and it seems desirable to continue this work with the hope of reaching the goal which science has so long sought.

Fur Farming Increasing in Wisconsin

THE RECEIPT of several carcasses of foxes for autopsy led F. B. Hadley and B. L. Warwick (Veterinary Science) to make a survey of the fur farming industry in this state.

In reply to a questionnaire, fifty-two answers were received from owners engaged in raising fur bearing animals in captivity in twenty-four counties. In this new industry Marathon county is an easy leader, 13 different ranches being located there.

Though the industry is comparatively new, the replies show that some Wisconsin men have been engaged in it for as long as 20 years, and decided activity has taken place during the last four or five years. The chief animals grown for their pelts are the foxes: the Alaskan silver fox, the silver black fox, and the crossbred fox being the most popular breeds while a few farmers raise the red fox. Skunks, minks, raccoons, wolves, and rabbits are also raised.

A total of 1,361 animals were reported, which gives an average of about 30 animals per farm. One thousand, one hundred and forty-seven acres of land were reported as being used strictly for fur-farming purposes. In comparing the number of young born last year with the number raised, it was found that some ranchers lost all of

FIG. 40.—ALASKAN SILVER BLACK FOX

Wisconsin fur farmers find that foxes in captivity thrive best when their quarters are kept in a sanitary condition and as nearly like those chosen by wild foxes as it is possible to provide.

their pups while others raised substantially all of the young produced. The average reported was 75 per cent, which may be considered a very good record in view of the fact that in this industry animals are being raised under artificial conditions which may vary widely from the natural.

While the fox industry is a relatively new industry in Wisconsin, artificial rearing of foxes has grown to the proportions of a large

business in some sections of the country. Prince Edward Island in Canada is perhaps the best known section for this business. Fine quality pelts bring several hundred dollars apiece, but it is difficult to get any satisfactory figures with reference to the differentiation of actual receipts for pelts or breeding stock. The final success of the business will, of course, have to rest in the sale of pelts rather than breeding stock.

Among the obstacles to success in this business, disease, worms, and insanitary conditions were reported as the principal causes of

FIG. 41.—THE LOCATION OF WISCONSIN FUR FARMS

The small black dots indicate the number of farms at each place.

loss. Mismanagement, the marketing of the pelts, feeding troubles, Canadian competition, lack of capital, failure to breed, and the disposition of the fox were given as other difficulties which some of the

breeders have met. Forty-six ranchers reported plans of expansion, and the number of animals which they expected eventually to maintain was stated to be from 40 to 100.

Ten leading fox farms were visited, and a wide difference was found in the equipment and management. The common size of pen used is 24 feet by 48 feet. The individual pens on most ranches were separated from each other by spaces varying from 18 inches to 16 feet. The primary object in having a double wall is to prevent fighting through the fence; and it is said also to be an aid in preventing and controlling disease. On one ranch there were a few holding pens separated only by a single fence, but these are used only a short time during the year. At the time of the visit to this ranch one valuable silver fox was suffering from the loss of a paw as the result of fighting through the fence. Another ranch visited was using the double partition only up to about six feet in height with a single partition above that, but this was not considered satisfactory. To prevent the animals from digging their way to freedom, the fence also extends into the ground about 18 inches to two feet, or else the entire pen is carpeted with netting. All pens were provided with an "overhang," a projection to the fence on the inside to prevent the escape of the foxes.

Some owners are emphatic in their contention that the only successful method of raising foxes is to have plenty of trees and rocks in the inclosure and to provide means for the animals to have plenty opportunity for digging, thus simulating natural conditions.

An observation tower is an essential part of the equipment of most ranches. A side location is favored because observers are not so likely to disturb the animals during the mating season.

Three general types of kennels were found in use: (1) a three-compartment kennel for one pen; (2) two single compartment kennels for one pen; and (3) underground kennels. The first two have their advocates, but the underground type is not favored by any. It is being tried, but appears to be too damp and musty and is therefore avoided by the foxes. Special ventilators are being used by some in the hope of making underground kennels more habitable.

Infestation of the intestines with the round worm (*Belascaris marginata*), one of the Ascarids, is the principal disease with which fox breeders have to contend. This is probably the result of the confinement of the animals to relatively small quarters, where there is usually little opportunity to keep conditions strictly sanitary. The most successful fox farmers treat the pups, soon after they appear out of doors and at regular intervals thereafter, to eradicate these worms. Most breeders use one of the several advertised remedies on the market for this purpose. In spite of this, some pups are occasionally lost because of this disease. Young fox pups a few weeks old sometimes contain hundreds of these parasites. In one that was examined in the laboratory 276 worms were found.

Reports from Canada indicate that the hookworm is a very serious menace to the industry there, but in the autopsy of Wisconsin foxes very few of these pests were found.

Rickets is somewhat prevalent, and the breeders are showing considerable thoughtfulness in planning the rations for their foxes with this in mind. Many eggs, much milk, and ground bone are fed along with such feeds as horse meat, beef, unpolished rice, oat meal, vegetables, and bread. These combinations provide a ration that aids in the prevention of rickets as well as in promoting the growth of the young animals.

Goiter in Calves and Sheep Prevented by Iodine

THAT goiter is common in some animals of the North Central states has long been known; and, in order to find methods of treatment and prevention of the disease in calves, F. B. Hadley (Veterinary Science) has undertaken its study.

Cases of goiter in calves have been reported from numerous places in the state, and a survey shows that the disease confines itself to certain herds rather than to any particular section of the state. Goiter is a diseased condition of the thyroid gland, which is located in the upper part of the neck. When this gland from affected calves was studied by means of the microscope, it was found to be much enlarged, due to increased number of cells.

In newborn calves the swelling may be so large as to compress the trachea and result in suffocation. In some cases the swelling gradually disappears without treatment; but with the administration of potassium iodide (KI) recovery occurs much more promptly.

In one herd of pure bred Guernseys, eight calves were born between January 28 and May 25, and all of them had goiter. The seven calves that lived out of this group were treated on June 2 by being given two grains of potassium iodide; and the treatment was continued daily for three weeks. At that time no signs of goiter could be detected in five of the animals, while there was a noticeable improvement in the other two; by August 1 all of them had fully recovered.

Although no potassium iodide was administered to any of the cows of this herd, none of the calves born during the succeeding 12 months was goiterous. The only change made in the herd management during that time was that the cows were required to take more exercise than before. Whether this helped as a preventive is not known.

As a method of prevention of goiter in calves, it is recommended that five grains of potassium iodide (KI), or sodium iodide (NaI), be given to each cow every second day during the last three months of the gestation period. This may be conveniently given by placing a five-grain tablet in the drinking cup or by dissolving the iodide crystals in water and then mixing with the feed or the drinking water.

This method of treatment is also recommended for sheep, the dose being five grains per week by mixing it with the salt. The amount

required for a given number of sheep may be determined by first emptying the salt boxes and then filling them with a known amount of salt by weight. At the end of a week the remaining salt is removed and weighed to find the amount consumed. A like quantity of salt is then mixed with as much potassium iodide (KI) or sodium iodide (NaI) as would be required to allow five grains per head per week. The mixing of a fresh supply each week is desirable because the material turns reddish in color when left exposed to the air.

It has been observed that goiter in newborn animals occurs almost exclusively on farms in sections where winter necessitates stabling between November and March. This is the season when the ration is likely to be restricted to *food and drink low in iodine.* Sows and ewes which have had access to green feed during the last three months of their gestation period seldom, if ever, give birth to goiterous offspring. Cows and mares may require a longer period on pasture to safeguard their prospective progeny against this disease.

Infectious Abortion in Swine

THAT infectious abortion in swine, if it continues to spread, threatens to menace seriously the swine industry is apparent from recent studies made by F. B. Hadley and B. A. Beach (Veterinary Science). Their work indicates that this disease is now prevalent to an alarming extent in Wisconsin and in other hog raising states as well.

The abortion disease in swine is caused by a microörganism which is closely related to but not identical with the bacillus which is responsible for most cases of abortion in cattle. This germ has been found in aborted pigs, infected afterbirths, and in the first milk of aborting sows.

When pregnant sows were inoculated with the abortion bacilli of swine, most of them aborted, but none aborted that were inoculated with strains of the organism recovered from cattle. The inoculation of pregnant cows with strains of abortion bacilli from cows caused abortion in these animals, but no effect was apparent upon pregnant sows inoculated with the same organism.

The investigators have concluded that the abortion disease of swine is much more likely to be introduced into a clean herd by purchase of swine from infected herds than by the feeding of dairy products contaminated with germs of bovine abortion, and it does not appear likely that sows will contract the infection from affected cows.

Blood tests were found to be the most satisfactory means of detecting the disease in swine, the agglutination method of testing being preferred. The average time required for abortion to result after a sow was infected was 23.2 days; in the cow it was 58.5 days. While infection may be contracted in various ways, sows seem to have considerable resistance against the organisms when taken by way of the

mouth; but when they are injected into the blood stream before breeding, it was found that 75 per cent of the pregnant sows aborted.

Infectious abortion in hogs seems to be a self-limiting disease in that a naturally acquired infection usually is followed by immunity which will protect some sows for a long period of time. The breeding efficiency of animals which have aborted is not necessarily impaired. This, however, depends upon the individual. Vaccination experiments justify the belief that this is a means of conferring active immunity and promises to be effective as a control measure. Whether it would be advisable to use vaccine generally in herds throughout the state has not yet been determined.

Contagious Abortion in Cattle

PROGRESS in the work being conducted to control contagious abortion of cattle is reported by Mr. Hadley. Careful study of the abortion vaccine after it had been kept in storage for varying lengths of time has shown that the microörganisms live for at least two months in a vaccine prepared with a physiologic salt solution and stored in a refrigerator. Five hundred doses of the vaccine were prepared and distributed for experimental purposes. This material was sent to veterinarians and farmers who were coöperating with the Department of Veterinary Science in the study of the results which follow the use of live cultures of abortion bacilli when applied as a vaccine to immunize open cows and heifers against the abortion disease.

The agglutination test on the blood serum of cattle must be made at least once every six months in order to detect incipient cases of infection. Otherwise the disease may make such headway that it would be impractical to control it by removing all reacting animals. During the year, 1,730 samples of bovine blood, 130 samples of porcine blood, 15 samples of ovine blood, and 25 samples of cow's milk were tested to determine whether abortion infection was present. Recommendations to the owners of the animals for the management of their herds and flocks to prevent and control the disease were based upon these various tests. The sum of ten cents per sample is being charged for making these tests to cover the cost of materials used.

Tuberculosis in Poultry

TUBERCULOSIS is gaining headway in farm animals to an appalling extent. It is by no means confined to cattle, as was at one time believed, for Mr. Beach has found it widely prevalent in hogs and to an alarming extent in poultry. In some localities practically all flocks of poultry on farms are infected. On account of the slow progress of the disease in individual birds, it is not recognized by the poultryman until many members of the flock become affected. Postmortem examinations were made in the

veterinary science laboratory during the past year on 300 birds of all ages and from different flocks. All of these fowls were affected with some kind of disease, and 18 per cent of them were found to be affected with tuberculosis. Of the adult fowls, 28 per cent were tuberculous.

Avian (fowl) tuberculin is being prepared and distributed by the Experiment Station to be used in detecting tuberculous poultry in the same way that tuberculin is used to detect this disease in cattle. As a means of control and eradication this product promises to be of considerable aid.

Danger Lies in Feeding Horses Silage

THAT there is an element of danger in the feeding of silage to horses appears probable from an investigation made by Mr. Hadley during the past year. A number of outbreaks of disease followed by severe losses have been reported where silage seems to have contained some substance which was toxic to horses. The disease has been variously termed forage poisoning, botulism, staggers, and ptomaine poisoning. It is most prevalent in Wisconsin during the warm spells of early spring.

The symptoms exhibited by horses suffering from this form of poisoning are given below, since they will aid veterinarians and farmers in recognizing cases of the disease in the early stages:

(1) Inability to swallow either liquids or solids.

(2) Paralysis of the tongue, which is shown by the animal being unable to retract this organ when it is withdrawn from the mouth.

(3) A constant flow of saliva, which hangs from the mouth in long strings.

(4) Attempts to eat hay, which is grasped by the lips, but cannot be carried into the mouth for mastication.

(5) When trying to drink, the lips pucker a little, but not the slightest movement is noticeable in the throat.

(6) The muscles that control the act of swallowing waste away rapidly, and a pinched appearance around the throat is observed.

(7) A thick, whitish discharge occurs from the nostrils.

(8) The pupils of the eyes dilate and are not responsive to light.

(9) At first the mind is clear, but later the animal may become delirious, and the hearing appears to be affected.

(10) The tail is so limp that it may be folded straight over the back like a rag.

(11) When the animals walk, they exhibit incoördination of movement and lack control over the muscles.

(12) Constipation occurs in most cases, but with little bloating. These symptoms become aggravated as the disease progresses, and after a few hours the animals become unable to maintain a standing position.

Though the exact cause of this disease is not definitely understood, Dr. Hadley believes that it is produced by a toxic substance formed by the *Bacillus botulinus* or some other disease-producing organism. For animals in the early stages of the disease, the use of a product known as botulinus antitoxin is recommended, but this is not effective as a curative agent in the advanced stages of the trouble. Purgatives and immediate change of feed are essential in the treatment of animals suffering from this form of poisoning.

Calf Diphtheria or Stomatitis in Wisconsin

A CONTAGIOUS and infectious disease in calves (known as necrotic stomatitis) has been brought to light in investigations by Mr. Hadley. This infection is also termed "calf diphtheria" due to patches in the mouth and throat that resemble those seen in human diphtheria.

In the herd first observed four calves had died and five were sick with the characteristic symptoms of the disease. The cause was found to be the *Bacillus necrophorus* (a microörganism often found in the intestinal organs of cattle where it usually does no harm). However, when the organism becomes highly virulent, it causes an inflammation in the tissues which finally destroys them. The following control means are advised:

(1) Separation of all affected animals from the healthy ones,

(2) Daily inspection of the mouth and throat of exposed animals,

(3) Swabbing of necrotic patches with a 3 per cent solution of potassium permanganate,

(4) Removal of all loose litter from the pens and disinfection with a reliable disinfectant.

Better Methods Important in Swiss Cheese Making

THE IMPORTANCE of growing starters used in the manufacture of Swiss cheese at the proper temperature has long been advocated by the Dairy Husbandry Department and to meet this need, two simple devices have been perfected under the direction of J. L. Sammis (Dairy Husbandry) within the last year. In the past when the starter was kept at too low a temperature, it often failed to produce the amount of acid necessary for the manufacture of the best quality of cheese; and consequently many cheese makers in the state have experienced trouble in the making of a first quality product for the reason that they did not provide a suitable place for the keeping of the starter cans. The first of these new devices consisted of an ordinary egg incubator lamp and regulator applied to a wooden box provided with suitable space to hold the starter containers. Since the temperature requirement for the satisfactory growth of the starter bacteria (*Bacterium bulgaricus*) is not a very definite one, anywhere between 100° and 113°F. being satisfactory, it was found

that this device very easily maintained a proper temperature. Some cheese factories in the state have already adopted the plan and are obtaining satisfactory results with it. One incubator manufacturer in the state has gone so far as to modify his machine by substituting jar and tube holders for the egg shelving, thus providing a cheap and efficient outfit for use by the cheese makers in keeping starter cans at a uniform temperature.

The second method used employed a double walled, galvanized iron jacket filled with cotton batting around cans of starter from 100 to 150 pounds in size. In such large quantities the insulation provided by this jacket is sufficient to keep the temperature uniformly high

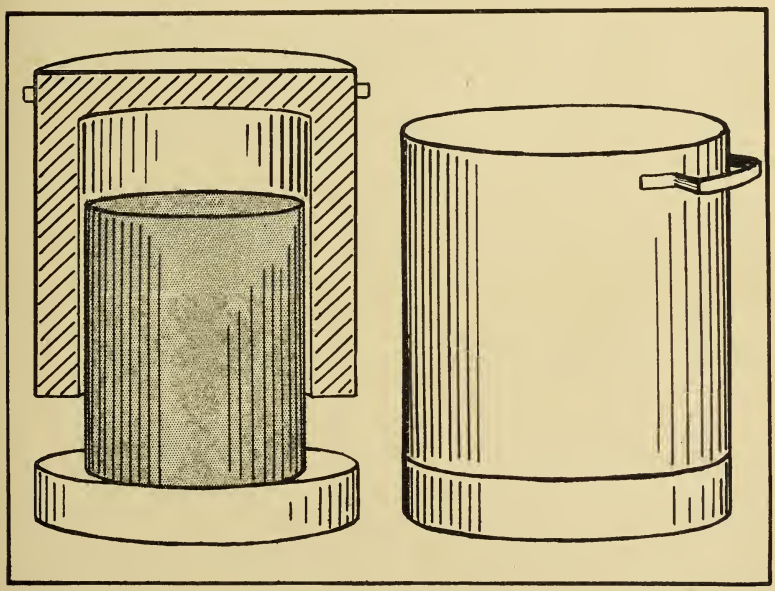


FIG. 42.—A SIMPLE STARTER CAN DOES THE WORK

The can of starter is placed upon an insulated base and covered with a double-walled iron jacket in which the interspace is filled with insulating material. It keeps the temperature sufficiently uniform for best results.

enough to permit proper growth and ripening. Several of these insulating jackets were constructed by the Dairy Husbandry Department and loaned to cheese makers with the result that in each case the cheese maker was able to construct an inexpensive and satisfactory jacket after using the one loaned to him through the Experiment Station. A convenient way to build the arrangement at the cheese factory is to use a twenty-gallon milk can surrounded by a double wooden box, the walls of which are filled with a six-inch layer of insulating material. A cover similarly insulated is put on top; or, if

the jacket is made of metal, it can be inverted over the can of starter on an insulated base.

Either of these ways is more satisfactory than the old custom of setting starter cans in the boiler room over night in the hope that they will keep a temperature which will produce a degree of ripening satisfactory for the manufacture of a first-class cheese. It is probable that the general use of some temperature controlling device in the keeping of starters will follow as the result of this work.

Trials with "Eye"-Culture.—In view of the variety of methods used by Swiss factory men and the discordant ideas held by them on many points, a number of questions constantly come up for solution which are often best settled by direct experiment. In April 1922 trials were undertaken to determine the value of eye-forming cultures developed and distributed by the United States Dairy Division through C. M. Gere, who has been working in coöperation with the Wisconsin Experiment Station. While these experiments have not settled the question with complete finality, it is apparent that the eye-forming culture, if intelligently used, will do much to give our Wisconsin-made Swiss cheese the high flavor which is commonly found in that of foreign make. From the work conducted so far, it appears that temperature of the curing room must be under control to avoid too great eye formation in the use of the eye-forming cultures; and while some inexperienced cheese makers were unable to get satisfactory results with their use, it is probable that further experiments will bring about a more extensive appreciation of them.

Salts Affect Heat Coagulation of Evaporated Milk

MILK condensaries frequently are troubled by a coagulation of the evaporated milk in the sterilizing process. This makes the evaporated milk curdled in appearance and practically unmarketable. H. H. Sommer (Dairy Husbandry) previously found that the calcium and magnesium salts, the citrates, and phosphates of milk have a decided influence on heat coagulation. Evaporated milk that coagulates in the sterilizing process frequently does so because of an excess of calcium and magnesium in the milk. This condition can be improved by the proper addition of sodium citrate, or disodium, or potassium phosphate.

This remedy the past year has been further applied on a commercial scale at condensaries with considerable success. At one condensary calcium chloride brine leaked into the milk. By the addition of sodium citrate the product was finally processed at 244°F. for 16 minutes. This striking illustration occurred on 50,000 pounds of milk, and it shows the marked effect of salts on the coagulation of evaporated milk. Certain condensaries are using disodium phosphate very successfully, and they are enabled thereby to extend the sterilizing process four or five minutes.

Mr. Sommer has begun a study of the causes for a variation in the salt composition of the milk which bring about this troublesome coagulation. Preliminary experiments have shown that the feed influences the heat coagulation of milk very materially. Fresh milk from one cow on dry feed coagulated consistently at 246°F. in two or three minutes. When this same cow went on pasture, the milk no longer coagulated at 246°F. in thirty minutes. The properties of the milk of three cows were also decidedly changed by feeding them from 50 to 200 grams of calcium carbonate (lime) per day. More extended trials of this matter are now in progress

Use of Alcohol Test Limited

THE ALCOHOL test has long been used as one of the methods of determining the quality of milk. If a precipitate formed in this test, the milk was supposed to be undesirable and therefore rejected or scored second grade. The reliability of this test has been further studied by H. H. Sommer and T. H. Binney (Dairy Husbandry). They found that the alcohol test is very decidedly influenced by small variations in the salt composition of milk. Calcium and magnesium salts cause a positive test but their effect is counteracted by the citrates and phosphates of the milk. It was shown that the milk of three cows which had been negative to the alcohol test became positive when liberal amounts of calcium carbonate (50 grams increased to 200 grams) were fed in the ration. The acidity was also found to be a factor in the alcohol test but of lesser importance in the case of fresh milk than the salt composition. Rennet-forming bacteria also cause a positive test.

The alcohol test, therefore is not to be wholly relied upon. It is shown that it depends largely upon the salt composition of the milk, which may vary widely, and bear no relation to the quality of the milk itself. Salt composition which causes a positive alcohol test is not undesirable, and such milk should not be excluded except, possibly for evaporated milk where its tendency to coagulate rapidly may be detrimental. The heat coagulation of evaporated milk and the alcohol coagulation are both influenced by the same factor; i. e., an excess of calcium and magnesium over citrates and phosphates. The value of the alcohol test then may be more significant in the selection of milk for condensing purposes than in other lines.

Denatured Alcohols for Fat Extraction Test

IN THE accurate determination of fat content of dairy products by the Rose-Gottlieb extraction method, grain alcohol is commonly used. On account of its cost, due to the tax and the restrictions placed upon its sale the desirability of using denatured alcohol for this purpose became apparent. Accordingly H. H. Sommer and K. V. Bryan (Dairy Husbandry) made a study of various substitutes and found that grain alcohol denatured by the addition of one-tenth

of its volume of wood alcohol or with one-tenth its volume of ether and three-twentieths of ammonia gave good results. Wood alcohol and iso-propyl alcohol were unsatisfactory.

Fishy Flavor of Butter

OCCASIONALLY there develops in butter, especially storage butter, a flavor which is variously described as resembling that of salmon, mackerel, and salted herring. This fishy flavor has been a depreciating factor of considerable importance in the butter trade ever since highly flavored butter was made and put into cold storage. Conditions under which this fishiness develops in butter have been studied by H. H. Sommer and B. J. Smit (Dairy Husbandry). Butter was made from pasteurized and unpasteurized cream; from low, medium, and high acid test cream; it was unsalted, medium salted, and highly salted; some of it was overworked, some exposed to the air, and other samples left in contact with metallic surfaces; and different temperatures of storage were also used.

After five months storage, fishy flavors were obtained. The most distinct fishiness was obtained from highly salted butter that had been made from high acid, unpasteurized cream in which iron lactate had been incorporated, and which had been stored at the higher storage temperatures. No fishiness was obtained in samples of low acidity, low saltiness, and in which oxidation was not favored.

The theory has been advanced that the fishy flavor is due to an organic compound known as *trimethylamine* (herring brine odor), which may be formed from another organic compound found in butter known as *lecithin*. Experiments were conducted with the emulsions of lecithin prepared from egg yolk to determine the conditions under which lecithin will decompose to yield trimethylamine. It was found that the lecithin emulsion yielded by far the largest amount of trimethylamine under the combination of the above named three conditions—high acidity, high salt content, and oxidation.

Trimethylamine or its salts when incorporated into the butter imparted to it the characteristic fishy flavor. This compound was also isolated from samples of fishy butter. The conclusion seems substantiated that fishiness in butter is due largely to the results of the chemical decomposition of lecithin into trimethylamine, and that the factors which seem to favor this condition are high acidity and high salt content in butter combined with the oxidation resulting from overworking in the presence of metallic utensils.

Cooperative Butter Marketing Needed

THERE IS a growing amount of dissatisfaction with the prevailing systems of butter marketing. Butter has long been marketed by the individual creamery shipping the same to adjacent available markets where it has been sold presumably on its merits but often without any knowledge of its origin. In view of

the fact that much improved methods have already been inaugurated in one Wisconsin county and have resulted in such signal success in the coöperative marketing of butter by shipping in car lots to eastern

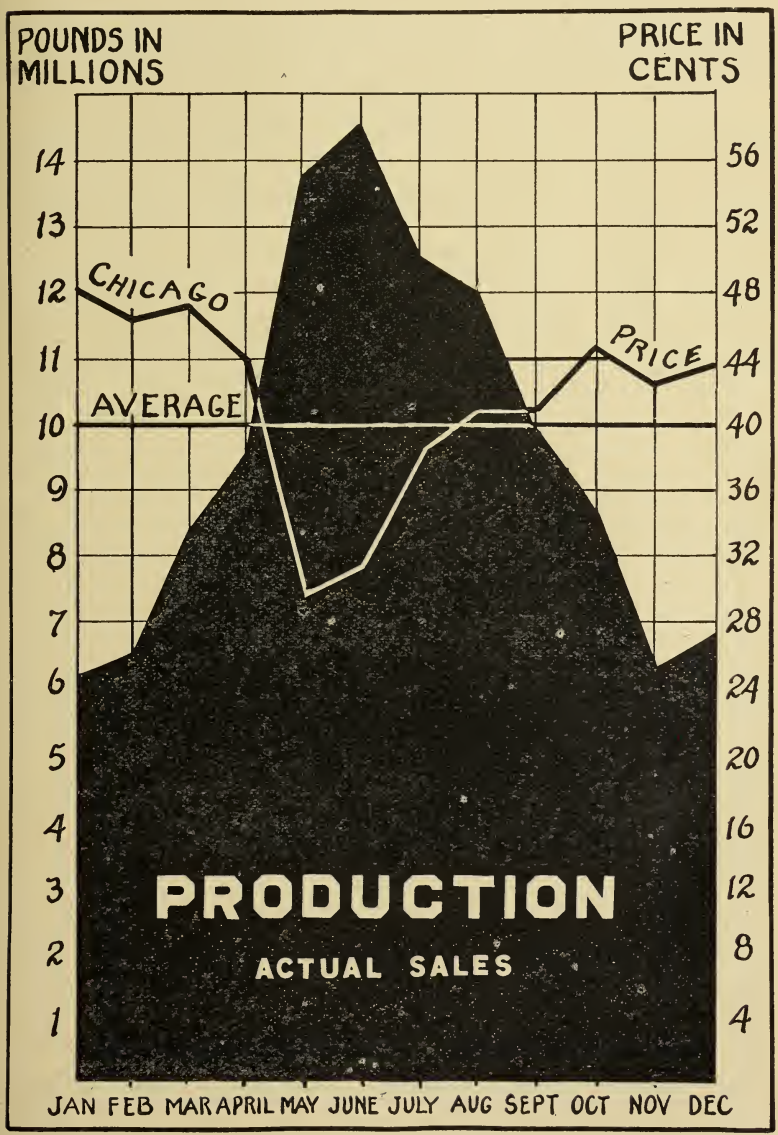


FIG. 43.—WHY BUTTER PRICES FLUCTUATE

Butter production and sales are high in the summer months with the result that prices tend to fall as production increases.

markets, it appears that a state wide coöperative organization for improvement in the marketing of butter is readily possible. Accordingly, Theodore Macklin and L. P. Gabbard (Agricultural Economics) undertook a survey of the operations of thirty-one creameries located in the counties of La Crosse, Monroe, and Vernon for the purpose of determining how coöperative creameries in general might improve their marketing conditions. A number of conclusions in accordance with the experience of creamery operators have been reached:

1. Many farmers in each community are not producing as high a grade of cream as is necessary to make the highest quality of butter. If the creamery refuses to accept the low grade cream, patrons shift from one creamery to another, and more creameries than are necessary to handle the butter fat are kept open for business with the result that unnecessary running expenses are incurred.

2. It is found that the cost of assembling butter fat, making butter, and placing it on the market by different creameries varied from slightly less than 2 cents per pound to 7.6 cents in 1921. Transportation cost varied from almost nothing to 3.75 cents per pound, and creamery operating costs ranged from 1.9 cents to 5.3 cents per pound. Generally the larger creameries can make butter at a smaller cost per pound.

3. The size of the creamery seems to bear no relation to transportation costs of cream and butter, but it does bear a direct relation to the cost of the creamery operations, which shows that the creamery manager is usually more expert in the making of butter than in marketing it.

4. There is a great variation in the prices which the different creameries receive for their butter from month to month and for the year. This is in part due to differences in the quality of the product, but undoubtedly the plan of selling also exerts an effect. The average price of butter sold to retailers was 4 cents per pound above that sold to wholesalers. Though the disposal of their product to retailers pays best, few creameries have developed this kind of market.

5. While there is room for improvement in all phases of creamery operations, the greatest need lies in the marketing end of the business where more expert service is required.

6. Expert sales service at a reasonable cost per pound cannot very well be obtained by local creameries individually, because they have too little butter to market. A better sales service, however, is possible at a small cost by federating coöperative creameries so that a large volume of butter will go to market through a single sales system. The development of such coöperative creamery federations that can establish their own selling system is the next logical step in the butter industry.

That the dairy industry in the state of Wisconsin needs a wider application of such methods is apparent when Polk county's achievements in this direction for the past few years are considered. Already, unit No. 1 of the Wisconsin Coöperative Creamery Association has been established in this county, and H. P. Sondergaard at

Balsam Lake is its field man. About 8,000,000 pounds of butter were shipped to New York and Philadelphia during 1921, and according to John Klinka, county agent for Polk county, an increase of approximately a million pounds in these eastern shipments will result in 1922. Twenty-eight coöperative creameries are included in this shipping unit, and twenty-one of them are in the field unit. According to Mr. Klinka, the organization has easily increased the income from butter for this territory by $50,000 in a year.

That there is every prospect of developing powerful statewide organization out of this Polk county idea is evidenced by the fact that 65 creameries are already members of the Wisconsin Coöperative Creameries Association. This organization has rendered signal service in reducing the shrinkage, which is ordinarily experienced in the shipping of butter, and in the promotion of more exact methods in the manufacture and handling of the product. With the premium that is offered for butter scoring 93 on the eastern markets, many Wisconsin creameries that formerly only attempted to make a butter scoring 92 are learning that with a little extra effort they can obtain a product of such quality as will enable them to receive the fancy prices paid by the trade for butter testing 93.

Through these efforts it is probable that we shall soon reach the time when all makers of first class butter will use only sweet cream and that butter makers who are trained to make a first class product only will be employed. When a first class product is combined with intelligent marketing, Wisconsin dairymen will reap their fullest reward for such effort. To provide suitable brand names for Wisconsin butter and then to market it through single representatives in the large eastern cities is another step which will naturally grow out of this organization work; but this, too, will depend for its success upon the quality of the product which is to be handled. The Polk county idea, whereby the quality of the product is so improved by the producers themselves that there will develop a market demand based on merit, is probably the natural solution of the problems of Wisconsin dairymen, and its gradual application on wider areas appears desirable.

The Town as the Farmer's Service Station

OUT OF a study of country neighborhoods made last year, an investigation of the service relationships between the farmer and the town has grown. The work is being carried on in three areas: eastern Dane county, the Elkhorn area in Walworth county, and the Waupaca area in Waupaca county, by J. H. Kolb (Agricultural Economics). This study includes the economic services, such as merchandising, marketing and financial, educational, religious, social, and the services of communication and organization. In one town, with a population of 490 people, 85 different agencies were discovered which have direct relations with the farming population which surrounds them. In another section including six small towns

it was found that the farmers furnished about 65 per cent of the patronage for the non-commercial agencies, such as church, school, social and fraternal organizations, but assumed only about 15 per cent of the leadership.

The town needs the farmer and the farmer needs the town. This relationship can be of more mutual benefit when given attention and when united effort is made for its organization than when it is neglected. It is probable also that this planned and orderly relationship will come about most readily when each group perfects its own organization and the cooperation is the result of federated effort.

An organized relationship between the town and the farmer is greatly dependent upon a thorough knowledge and mutual understanding regarding the services and functions which one group performs for another. Each group must know something of the difficulty of the costs, problems, and needs of the various services. The process is educational and it is necessary to establish confidence.

The mainspring of this whole scheme of organization will always be that of motive. Any proposed activity in order to be assured of confidence and permanency must have a definite purpose and render a worth while service.

Analysis of Costs Shows Why Some Farms Pay

SOME FARMS pay while others of similar soils and topography, with the same seasonal conditions and identical markets, fail to do so. During the last few years there has been a general decline in prices, and those of farm commodities have remained at the bottom of the list. Under such conditions many farms, which during other times made money, have lost heavily. Large farms generally have been heavier losers than the small ones; and the few farms which actually made money were distributed among all sizes from the smallest to the largest.

A study was made in Walworth county under the direction of P. E. McNall to determine why some farms paid and to learn, if possible, to what extent it is desirable to supplement the dairy with other lines of income. It was found that the two outstanding ways in which the farms that made money differed from the others were the increased number of sources of income for the farm and the greater production of the dairy herd.

The well diversified farms, or those having four or five sources of income of more than $100 each, made considerably more than the poorly diversified farms. In order of their importance the chief incomes were obtained from dairy products, hogs, young cattle, poultry, grain, hay, and truck crops. The less diversified farms depended almost altogether upon dairy products for their income.

Good diversity provides opportunity for the better use of man and horse labor and for the utilization of by-products such as skim milk from the dairy herd and to spread the risks of the business. Unfavorable weather conditions or live stock diseases seldom affect

more than one crop or more than one group of animals at a time, and the farmer having several sources of income is not likely to be hit in all of them at once.

In this study it was also shown that, where average production per cow in the dairy herd was low, the income from this source was also low. The *average* production of milk per cow (5,600 pounds in Walworth county), was not enough to be a paying proposition. As the production per cow increased from an average of 4,625 pounds in the lowest herd to 8,138 pounds per cow in the best herd, the average farm income increased from $476 to $1,205. The cost of milk produced in this case decreased $1.19 per hundred weight.

The amount of feed and the hours of labor required to produce 100 pounds of milk were considerably less with high producing than with low producing herds. The greatest saving can be made in the case of grain and other concentrates. In herds where the average production per cow was as low as 5,000 pounds or less, 38 pounds of concentrates were used to produce 100 pounds of milk, while only 31 pounds were required in herds where production reached from 5,000 to 7,000 pounds per cow. In those herds where it ran above 7,000 pounds per cow 27 pounds of concentrates were used to produce a hundredweight of milk.

It appears that many farmers fed too heavily of grain in the ration for their farms to be profitable. On thirty-four farms, where on an average 3,000 pounds of grain and other concentrates were fed per cow, the average milk production was 5,900 pounds. This shows that 60 pounds of grain and other concentrates were used to produce 100 pounds of milk. On one hundred other farms, where between 1,000 and 2,000 pounds of concentrates were fed per cow per year, the average production was 6,000 pounds per cow and the amount of concentrates used for each 100 pounds of milk was 26 pounds. On these farms the net return per cow was $54 larger than on those where the heavier grain rations were fed.

Farm Tenancy Increasing in Wisconsin

LESS FARM tenancy is found in Wisconsin than in any of the bordering states. For the state as a whole the amount of tenancy is about 14 per cent, a very large part of which is found in the southern and eastern counties. In some of the southern counties the tenancy runs above 30 per cent while in some of those in the extreme north it falls below 5 per cent. On the whole, there is a very slight but gradual increase in farm tenancy in the state, most of which seems to occur in counties where the percentage is already high.

A recent study directed by B. H. Hibbard (Agricultural Economics) covering farms in Green, Rock, and Jackson counties shows some interesting facts. The investigation showed that in all of these counties the owned farms were smaller than the tenant farms, but

the tenant farms showed the larger proportion of tilled land, while the owned farms had the larger proportion of pasture.

Over a period of ten years it was found that 70 per cent of the owned farms had made important improvements at an average value of $1,119; while on the 57 per cent of the tenant farms, on which such improvements were made, only $526 were spent on an average. Less than two-fifths as much improvement was being made on tenant farms as on owned farms.

In the Green-Rock counties district the tenants owned almost as many automobiles and 10 per cent more tractors than were found among the land owning farmers. But in Jackson county the tenants owned relatively only about four-fifths as many of each.

As in other surveys made, it appears from this study that about 46 per cent of the tenants are relatives of the landlord and that in both these districts tenancy in most cases is merely a step toward land ownership.

Fertilizer Needs of Soils Determined by Greenhouse Tests

FROM THE residual soils of unglaciated southwestern Wisconsin and the limestone region which lies along the shore of Lake Michigan to the level and undulating sands, loams, and clays of the north, a great variety of soil types is found. In so wide a range of soils there naturally exists a great variety of soil problems. To determine more definitely the fertilizer needs of various Wisconsin localities, 26 different soils from 17 counties of the state were studied during the past year under the direction of E. Truog (Soils).

Chemical analysis and greenhouse tests were made. The soils were placed in two-gallon jars and treated with lime and fertilizer, both singly and in various combinations, and alfalfa was sown in all of the jars. With the proper treatment, it was possible to make alfalfa grow luxuriantly on all of the soils, which varied from non-acid to very strongly acid. How they responded to liming is shown by the following data:

(a) Three non-acid soils—none responded to lime,
(b) Two very slightly acid soils—none responded to lime,
(c) Six slightly acid soils—three responded to lime and three did not,
(d) Six medium acid soils—all responded to lime,
(e) Six strongly acid soils—all responded to lime,
(f) Three very strongly acid soils—all responded to lime.

The results indicate that when a soil is not acid or only very slightly acid, lime is usually not needed even though the alfalfa plant is extremely high in lime requirement. If soil is slightly acid, however, lime must be used to obtain best results unless the soil is very high in fertility. When soil is more than slightly acid, lime should always be used for growing this crop.

As shown in the following list, most of the 26 soils also responded to treatment of phosphate and potash fertilizers.

(a) Seven responded to phosphate alone,
(b) Three responded to potash alone,
(c) Eight responded to a combination of potash and phosphate,
(d) Eight did not respond to either.

Of the eight soils which responded neither to phosphate nor to potash, seven responded to lime leaving only one of the 26 which did not respond to some treatment. Since alfalfa is one of the most exacting crops in regard to its lime requirements and fertilizer needs, these results emphasize the fact that proper soil treatment should precede the seeding of this crop.

Methods of Applying Fertilizers

FERTILIZER research has been carried on for several years through fellowships established by the National Fertilizer Association, and during the past year H. J. Harper, working with E. Truog (Soils), has been successful in obtaining some notable increases with oats by means of fertilizer treatment. It was found that small amounts of fertilizers give better results when applied in the drill row than when applied broadcast. In the case of oats maturity was appreciably hastened by the use of phosphate and potash. Studies of the effect of hill application of fertilizer with corn on the root development have also been made. When the soil was washed away from a number of hills of corn, it was found that the use of fertilizer in this way did not restrict growth either in amount or extent—in fact, it usually causes an increase in the root development.

Investigations as to why some plants such as potatoes are easily prevented from coming up when fertilizers are applied in certain ways while other plants like corn are not so easily affected, have been undertaken by O. C. Magistad under direction of E. Truog (Soils). He has found that the osmotic pressure of the juice of potato sprouts and certain other sprouts is very low compared to that of the sprouts of corn. It is possible, therefore, for fertilizer in contact with potato sprouts to draw the water out of them and cause them to dry up. Corn sprouts are not nearly so easily affected. This indicates that, in the case of potatoes, fertilizer should not be applied directly over the seed in large amounts, but rather it should be mixed with the soil, and it would probably be better to apply it along both sides of the row rather than near the seed unless the application is made broadcast, which is probably most satisfactory.

In this connection a study of the effect of fertilizer in increasing the salt concentration and the osmotic pressure of the corn sap and its relation to freezing has been made. It has been found that the use of fertilizer in the hill may increase the salt concentration of the corn sap sufficiently to enable it to withstand a lower temperature than the unfertilized corn.

Spots on Alfalfa Leaves May Mean "Potash Starvation"

IN THE study of these 26 Wisconsin soils, the greenhouse tests indicated that very frequently potash was the limiting factor in alfalfa growth; and where this condition obtained, characteristic white spots appeared first along the border of some of the leaves and later spread over nearly the whole leaf, which then became yellow in color. These markings showed a distinct pattern-like appearance and cannot be confused with white spots upon the leaves from other causes.

This discovery was brought to the attention of the Extension Service workers so that they might make observations of the alfalfa

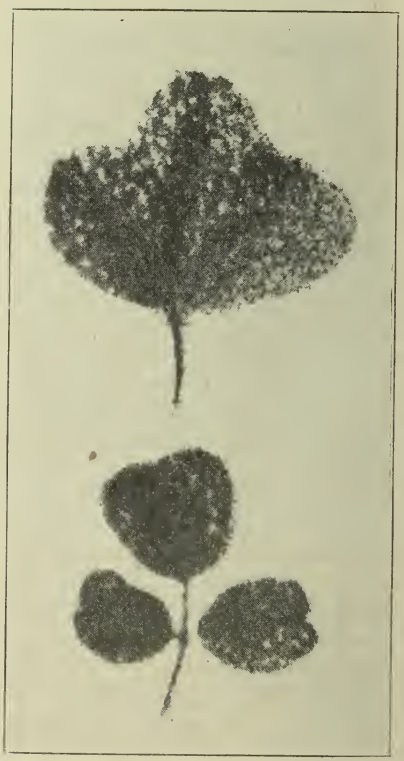


FIG. 44.—ALFALFA LEAVES SHOW POTASH DEFICIENCY

Potash is frequently a limiting factor in growing alfalfa, and often this condition brings about the characteristic spotting of the leaves as shown above.

fields in the state to determine, if possible, whether other indications of "potash starvation" could be found. As a result of this work, a number of cases have been reported, which seem to show that it is probable, potash is very frequently a limiting factor in the produc-

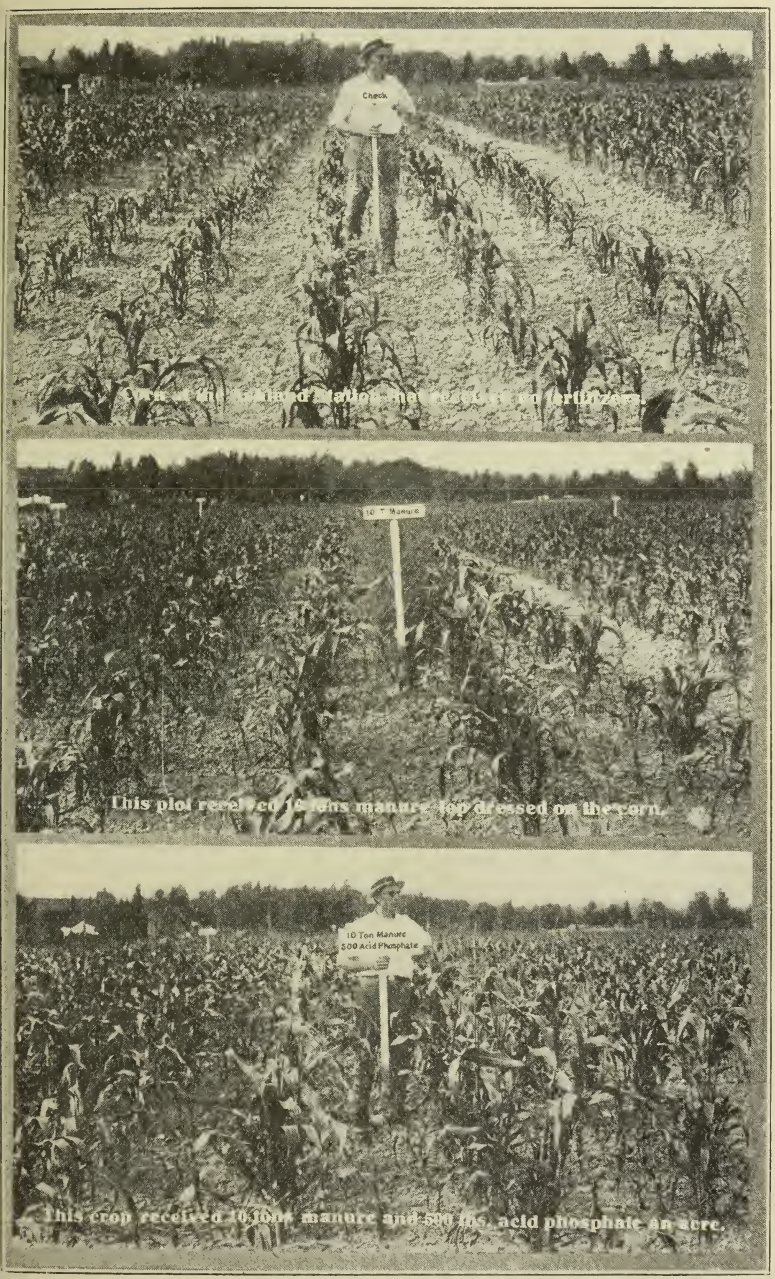


FIG. 45.—ACID PHOSPHATE IMPROVES CORN CROP

tion of the alfalfa crop. The greenhouse trials on this work seem to be very definite and conclusive, but a wider field experience will settle this question with more finality. For the present these symptoms on the leaves may possibly serve as a method of detecting the lack of available potash in our soil.

Phosphate Fertilizers Produce Well at Ashland

IN EXPERIMENTS conducted on a large number of plots with corn, barley, oats, and clover rotations, and on rutabagas at the Ashland Station by the Soils department, the work of the past year has verified earlier findings in regard to the beneficial effects of phosphate fertilizers. In oats, increases of nearly 10 bushels per acre were obtained in some of the plots where phosphate fertilizers were applied in combination with manure, and a gain of five bushels per acre resulted from the use of manure alone at the rate of 10 tons per acre. In the case of clovers even more striking differences

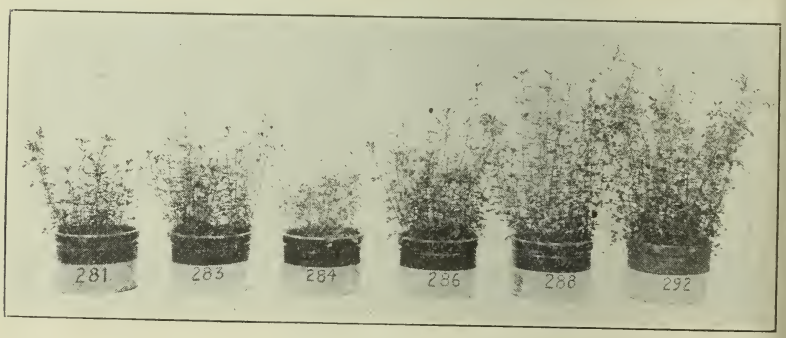


FIG. 46.—ALFALFA ON SANDY SOIL, MEDIUM ACID, AND LOW IN PHOSPHORUS

Alfalfa responded to lime, phosphorus, and potassium: 281 no treatment, 283 phosphorus, 284 potassium, 286 phosphorus and potassium, 288 lime, 292 lime and phosphorus and potassium.

were obtained; manure and acid phosphate showed an increase of 546 pounds per acre over the check plots, while plant residues and rock phosphate increased the yield nearly 1,100 pounds per acre.

Rutabagas require large amounts of phosphates for successful development, and for that reason this crop is very frequently used to determine the phosphatic needs of the soil. In past years this crop has been grown as a substitute for corn at the Ashland Station on account of the high yield and excellent quality of the roots obtained. It has been found to be a much more dependable crop than corn, and its yields are as a rule about twice as large on a given acreage. In fertilizer trials the response of the rutabaga crop to various treatments was rather striking, the yield in some cases being

increased more than 50 per cent over that of the untreated plots. The following table shows the average result obtained with the rutabaga crop under various fertilizer treatments.

Treatment	Rutabagas 2-year average
Plant residues and acid phos. 400 lbs.	21,590
10 tons manure and acid phos. 400 lbs.	27,310
Manure	23,454
No fertilizer	18,020

Why Some Soils Become More Acid Than Others

UPLAND soils on weathering become acid because the bases, such as calcium and magnesium, are leached away more rapidly than the acids, and some of our soils have become much more acid than others even though they have not undergone a greater degree of weathering. It was thought that the reason for this might be due to the fact that some minerals on weathering leave much more acid residues than others; and therefore the amount of acidity which developed in a soil might be dependent largely on the relative amounts of the various minerals present in the rock from which the particular soil was formed. Investigations have been carried on during the past year by C. D. Samuels under E. Truog (Soils) in order to determine this fact.

In this work ten different minerals were ground to a fineness where they would pass through a 100-mesh sieve; and then weathered and leached by treating them with carbonated water for 42 days. The amount of material dissolved in this process was determined every two days by filtering and evaporating the solution, then weighing There was a distinct difference in the acidity of the residues from the dissolved residues. By placing litmus paper in contact with the minerals left after the extraction, the point at which materials became acid was noted; and the acidity of the residue was also determined by means of the Truog test and the hydrogen electrode. the various minerals, and from this it has been concluded that the original make-up of the soils is an important factor in determining the strength of the acid formed on leaching. The results indicate merely that one of the reasons why some soils become much more acid than others is the larger proportion of certain minerals which they originally contained. The micas muscovite and biotite are abundant in some soils and weather rapidly into distinctly acid residues, which may account for the high acidity of such soils.

In four different upland soils where the organic matter was removed by treating them with hydrogen peroxide, it was found that, after the removal of the organic matter, the soils showed an even greater degree

of acidity than before, which indicates that the acidity of upland soils is largely due to mineral acids rather than to organic residues.

A Comparison of Soil Acidity Methods.—A comparison of three different methods of testing acidity—the hydrogen electrode, the sugar inversion method, and the Truog Test—was made on forty-two different soils by F. W. Parker and O. C. Bryan (Soils). The results indi-

FIG. 47.—ALFALFA ON A BLACK SILT LOAM, STRONGLY ACID, AND LOW IN AVAILABLE PHOSPHORUS

Alfalfa responded to phosphorus and lime. Lime alone gives no increase, while in combination with phosphorus it gives a marked increase over phosphorus alone:

240 no treatment, 241 phosphorus, 242 potassium, 244 phosphorus and potassium, 246 lime, 252 lime and phosphorus and potassium.

cated a fairly good correlation between the three methods used. The sugar inversion method and the Truog Test correlated better than either of them did with the results obtained by the hydrogen electrode.

Liming Shows Good Results at Spooner

CONTRARY to the results of previous years, the 1922 hay crop, both first and second cuts, showed decidedly improved yields at the Spooner Station where liming was practiced. In some of the plots the lime areas showed increases of over 50 per cent over the unlimed; and on an average all of the limed land produced over 30 per cent more hay per acre than the unlimed areas.

One of the striking things exhibited in these liming experiments was the fact that weeds early gained a foothold on the unlimed land. As the alfalfa becomes weakened through unfavorable conditions, it readily yields to the encroachments of the weeds which are competing with it. While no exact data are available, the best estimate placed the percentage of weeds in the unlimed alfalfa hay at about 15 per cent, which shows that lime in this case influenced the quality as well as the quantity of the crop.

Fertilizer Work at Spooner

GENERAL fertilizer work has been carried on at Spooner since 1917 under the direction of F. L. Musbach and A. R. Whitson (Soils Department); and in the six years of work considerable organic matter in the form of green manure crop has been added to a soil which was originally low in this essential substance. In fact, this sandy soil has been supplied with organic matter to such an extent that at present the yelds of crops are not markedly increased by the use of stable manure or manure reinforced with commercial fertilizers.

In the past year a supplementing of manure with varying amounts of phosphates has not shown profitable increases on the light soil at Spooner, and manure alone in some cases yielded more than the plots

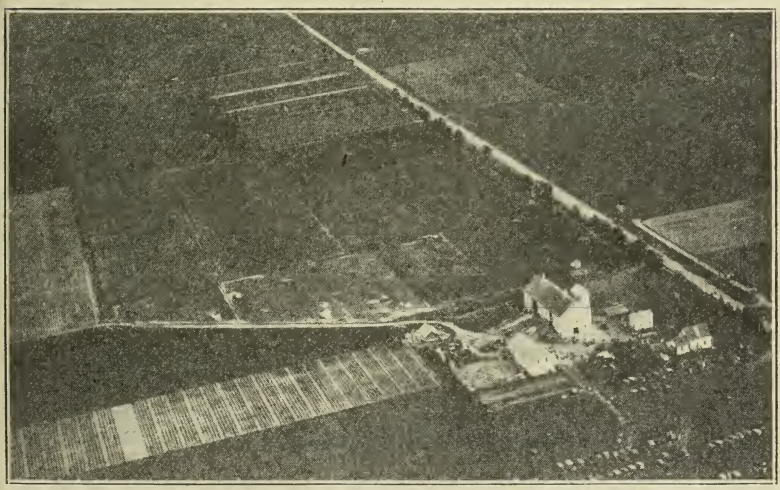


FIG. 49.—AEROPLANE VIEW OF MARSHFIELD BRANCH STATION (FARM NO. 2) SHOWING EXPERIMENTAL PLOTS

On the right of the highway the plots of farm No. 1 of the Marshfield Station are shown. Upward of 600 plots devoted to experimentation in soils and crops are found on farms No. 1 and 2.

on which a combination of fertilizers was used. This is doubtless due to the unusually high content of phosphorus in the manure coming from the feeding of more concentrates high in that element than the ordinary farmer feeds.

Observations of the work at Spooner indicate that distributing fertilizer over two crops instead of one shows consistent increases in yields; and as the work continues it is expected that the distribution of phosphate fertilizers over two crops will be found good practice.

How Can Stable Manure Be Best Utilized

QUESTIONS in regard to the rate of application, the place in the rotation, and the best method of applying barnyard manure as a fertilizer are often asked. In order to find satisfactory answers to some of these questions as they may apply to the sandy loams in some parts of the state, experimental work was begun in 1918 at the Spooner Branch Station. Compilation by Messrs. Musbach and Whitson of the results for several years show that top dressing is a slightly better practice than plowing under. When manure was applied to corn ground and thoroughly disked in, the following results were obtained.

Treatment with yard manure	Rye		Corn	Hay
	1920–22	1922	1920–21	1921
	Bu.	Bu.	Bu.	Lbs.
9 T. plowed under	19.40	21.27	44.68	1589.0
9 T. top dressed	21.37	23.40	46.51	1621.6

Green Manuring Alone Does Not Maintain Fertility

THAT green manuring alone is not sufficient to maintain the yields of crops grown was demonstrated in recent years in experimental work at the Spooner Branch Station. In these trials neither stable manure nor commercial fertilizers were used since the work was begun in 1914, and a rotation of corn, oats, potatoes, and clover was used. Green manuring crops, such as lupine and sand vetch between the rows of corn and potatoes, soybeans alternated with corn and followed by clover after potatoes, and serradella alternated with corn and seeded to rye after the potato harvest, were tried over a period of years. The results of the work in 1922 show that all of the plots have fallen off considerably in yield from the average of the four preceding years. While green manure can be used to make the fertility in the soil more rapidly available to the crops grown, the results of these experiments indicate that the practice in itself is entirely insufficient to maintain crop yields on this soil type over a long period of time.

Deep Tillage Trials at Ashland

EXPERIMENTS at the Ashland Station for several years have shown that deep tillage increases slightly the yields obtained from most crops, but the difference produced by this treatment is not enough to make it profitable. The cost of applying such treatment is too high, and the returns this year corroborate those reported earlier that make it inadvisable to advocate this method.[6]

The result of trials for several years is that fall plowing to a depth of 6 or 7 inches is the most satisfactory practice in the long run; and on the heavy soils in that section of the state this practice is recommended.

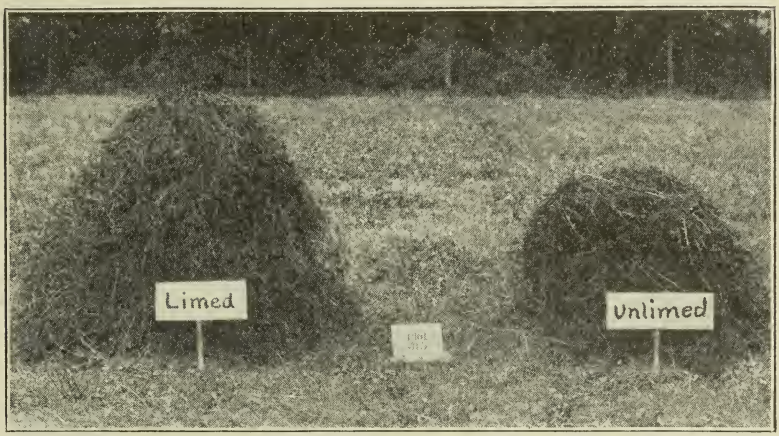


FIG. 50.—MANURED AND PHOSPHATED PLOT AT THE SPOONER STATION

Limed plot yielded 4563 pounds and the unlimed 2893 pounds.

Managing Sandy Soils at Hancock

IN VIEW of the fact that about one-fifth of the total soil area of Wisconsin is of a more or less sandy nature, the problems connected with the farming of these light soils become increasingly important as more and more of this land is brought under cultivation. The Hancock Branch Station was established in the sandy section of the state in 1917 for the purpose of determining which crops, fertilizers, and cultural practices are most suitable for such land. Continued studies of these problems have been made during the past year by A. R. Whitson and A. R. Albert (Soils) with special reference to crops and fertilizers needed on the sandy soils at Hancock.

Fertilizer and lime trials were conducted with a three-year rotation of corn, rye, and clover or soybeans. It was found that on these light soils the plowing under of manure for corn, rye, and soybeans was most satisfactory; while top dressing seemed to produce a higher yield in clover. An application of eight tons plowed under for corn increased the yield 19.3 bushels per acre over untreated plots; the gain in rye was 4.4 bushels and in hay 319 pounds per acre. At current prices the increase obtained from the manure over a three-year period is valued at $16, which makes a return of $2 for each ton of manure applied.

Studies to determine the relative needs of different plant food elements showed that available potash and nitrogen are lacking and

that, when commercial fertilizers are substituted for stable manure, it is essential that these elements be supplied. Whether it is profitable to supply potash fertilizers in addition to manure has not yet been determined, but the addition of phosphates has produced small but consistent crop increases. The method of application of commercial fertilizers does not seem to make any appreciable difference. Beneficial results were also obtained by the use of lime, but the influence of an application of one ton per acre seems to be almost as effective as larger applications on these sandy soils for clover.

Crops for Sandy Soils.—That alfalfa is one of the most successful crops on these sandy soils when properly managed has been amply demonstrated. The 1922 yield of this crop on land seeded four years ago was 5,300 pounds of hay per acre in two cuttings, and on fields seeded three years ago the average yield was 4,700 pounds per acre. Alfalfa, however, requires heavier applications of limestone than other legumes; and, in addition, it should be manured or treated with phosphate and potash fertilizer. Potatoes or corn should follow alfalfa in the rotation; and, after cropping the fields for one year, it should be re-seeded to alfalfa. This practice does not permit a constant three-year rotation in all fields, so that the retention of clover or soybeans, in rotation with corn and rye on the main fields of the farm seems desirable. Potatoes should only be grown on the better portions of the sandy areas, and it is necessary that the crop be well fertilized. When grown after alfalfa, the potato crop provides excellent opportunity for the preparation of the ground for re-seeding to alfalfa.

Progress of the Soil Survey

IN TWENTY-SIX Wisconsin counties the field work of a detailed soil survey has been completed, and work in the two additional counties of Pierce and Monroe is now in progress. A general reconnaissance survey to assist primarily in land settlement was completed several years ago, and the next step in the work will be to complete the detailed survey by counties as rapidly as this work can be conducted. During the field season of 1922, a total of 761 square miles have been mapped.

During the past year some new phases have been stressed in addition to the usual system of soil mapping, which has been in progress since this work began. Much attention has been given to topography, because it is one of the determining factors in farm operations and in the value of farm lands. A considerable number of calcium and magnesium determinations covering the most important types of soil mapped have also been made during the past two years, and surprising variation in total calcium content of the soils has been found. Most of the heavier types of silt and clay loam are fairly well supplied with lime. The amount of lime in the silt loams of central and northern parts of the state, such as Colby silt loam and the Kennan fine sandy loam, is as large as that in the silt loams of southwestern Wis-

consin and nearly equal to that in the southeastern portion of the state, while certain types of sandy soil and fine sandy loam derived from members of the Potsdam sandstone series proved to be very low in their total calcium content, there being in many cases less than one-third of the normal amount present. This information will be very helpful in determining the needs of lime as a fertilizer.

In the peat soils a remarkable variation in the lime content has also been found. The peats from the southern part of the state have

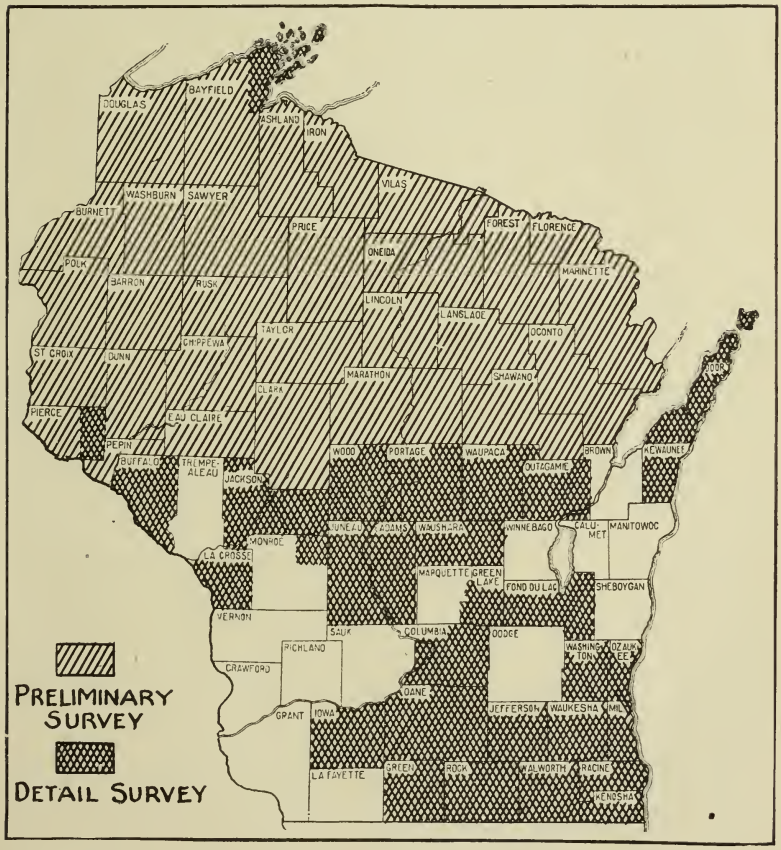


FIG. 48.—THE SOIL SURVEY NEARLY COVERS WISCONSIN

Reconnaissance survey maps are available of the northern counties, and detailed maps are prepared on the southern counties which have been surveyed.

from 1.5 to 3 per cent of total calcium, while those from certain areas in central and northern Wisconsin are as low as 0.1 per cent. In others words the southern peats contain ten times as much lime as some of those in the northern parts of the state.

It is already evident from this work that the total content of the calcium in the soil must be considered as well as the degree of acidity in determining the amount of lime that should be applied. The information regarding the lime content of our soil will doubtless also assist in determining the need for lime in the rations of animals produced in those sections of the state in which the soils are found to be exceptionally poor in calcium.

As a part of the field work in the mapping of soils, examination of all limestone and marl deposits which are likely to be used as sources of agricultural lime is being made. Twenty-five different deposits in Pierce county have already been examined in an effort to assist the farmers in finding sources of lime which will reduce the cost of hauling. In order to make the soils maps of the greatest possible usefulness in banks and schools and by the public in general, a new legend has been devised whereby the data can be summarized upon the map itself.

Deep Ditches and More Tile for Drainage

CONSTRUCTION of drains on large areas of marsh land in central Wisconsin was begun in 1901. The work has been carried on continuously ever since that time and is still in progress. Its importance in Wisconsin is indicated by the fact that prior to 1920 over $4,600,000 has been expended on land drainage work covering almost 800,000 acres. The object of this work is largely to drain the peat, muck, and sandy marsh land which has been too wet for farming. The major portion of it has been done in Juneau, Portage and Wood counties.

The total area of swamp lands and periodically wet lands in Wisconsin that could be drained profitably has been estimated 3,500,000 acres. The redemption of this area or such of it as is suitable for agricultural purposes can only be accomplished by drainage; in many places construction of roads and proper sanitation can only be achieved in this way. It is therefore obvious that the future work of the drainage engineer will be one of increasing importance in the state.

There are two ways to drain land. Deep outlet ditches will do the job if they are close enough together, or shallower and fewer open ditches will do it if supplemented by lines of tile from 4 to 8 rods apart. The big question usually is, which method is the cheaper. Observations made during the year in the Portage County Drainage district by E. R. Jones, O. R. Zeasman, C. Helwig, and S. Norling* (Agricultural Engineering) indicate that peat soils with a *sandy subsoil* can be most easily drained by means of large deep ditches which may be as much as a mile apart, while shallower ditches are less satisfactory and must in nearly all cases be supplemented by tile. Furthermore it is doubtful if the expenditure involved in tiling can be justified except

*In cooperation with United States Department of Agriculture.

where intensive cropping is practiced. Similar results were also observed in the Cranberry Creek and the Little Yellow drainage districts in Juneau county.

One mile of open ditch 6 feet wide at the bottom, 8 feet deep, and 22 feet wide at the top costs about $3,200, which is about five dollars an acre when distributed over a section of land. Satisfactory tiling cannot be done at so low a cost.

As a result of the extensive drainage operations in Wisconsin, engineers have concluded that peat and sandy marsh lands in the central part of the state usually can be drained at a reasonable cost. In the district examined in the largest marsh areas of the state it appears that sufficient returns may be secured from properly drained marsh lands to justify capital expenditures of approximately $15 per acre for main outlet ditches spaced from ½ to 1 mile apart on comparatively flat land. Such expenditure should cover also the construction of border or diversion ditches which are necessary to intercept seepage.

The peat and sandy soils of this region do not become overdrained nor too dry on account of deep drainage, as is sometimes believed. The opposite of this, rather, has been observed. Shallow drainage during the early part of the growing season prevents plant roots growing to a proper depth to sustain growth during the later dry periods. No cases have been found where shallow drains afforded good drainage, but all observations indicate that drains deep enough to keep the groundwater 4 to 6 feet or more below the surface are necessary. Finally, an all important matter in connection with drainage work is maintenance. After drainage ditches and outlets are constructed, they must be kept in condition to operate. Full responsibility for maintaining drainage should be given the drainage districts, and definite methods should be established for doing this work.

Drain Tile Investigations

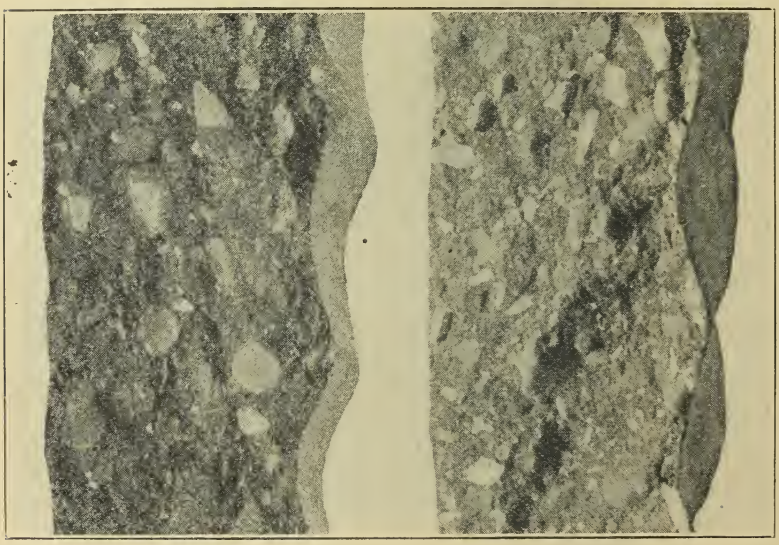
OBSERVATIONS by E. R. Jones and O. R. Zeasman (Agricultural Engineering) have been continued through the year on the subject of concrete drain tile. As the methods of manufacture are improved, an increasing durability in concrete tile is obtained. With the use of a cleaner aggregate, a wetter and richer mixture, firmer and more thorough packing, and curing in a steam room for a longer period of time, a tile of greater and more uniform density, reduced water absorbing capacity, and more endurance is produced. Some factories are still making poor concrete tile.

The better grades of concrete tile compare favorably with good shale tile. The severest test of tile is where it is placed in peat soils. Specimens of good concrete tile that have been lying for two years in the peat of the University Marsh show only a trace of disintegration at the water line on the outside, but some specimens of porous concrete tile showed general softening after only one year's contact with the peat. In clay soils or clay under peat it has been shown that good

concrete tile are satisfactory, which makes them adapted to at least 75 per cent of Wisconsin lands ready for drainage.

The problem of the durability of soft, porous, laminated, surface clay tile seems to be equally great. Some soft clay tile laid in Wisconsin in 1856, three feet under ground, are still in good condition. It is believed that their state of preservation is due to their freedom from lamination. Of course, they froze every winter but they were always empty when they froze and did not thaw out until spring. Furthermore, they were burned with a wood fire in the process of manufacture.

The difference between the dry weight and the wet weight of a tile shows its absorption. The dry weight is obtained after three hours' drying in a warm oven. The wet weight is found by weighing immediately after taking from water in which the tile has first been



(A) (B)

FIG. 51.—MANNER OF BREAKING IS TEST OF CONCRETE

In good concrete tile the stones must break clean, (A) while in the poorer grades they often are stripped out of the aggregate without breaking (B).

boiled for five hours, and then cooled. Clay or shale tile that absorb water to the extent of more than 14 per cent of their dry weight are undesirable and if more than 20 per cent their life is short, because frequent freezing and thawing will quickly cause them to crumble. Concrete tile with an absorption greater than 7 per cent are too porous to be recommended, particularly in peat or sand under peat.

The detection of poor clay or shale tile is relatively easy, because it can be determined by scratching the surface with a nail or examining the tile walls for laminations. If the surface scratches easily or if there is excessive breakage in shipment, it may be concluded that the tile

is too soft. Lamination may be detected by an attempt to split the tile walls with a knife.

To test the qualities of a concrete tile is a somewhat more difficult problem. One test is to break the tile and observe whether the pebbles have been broken squarely or whether they have been stripped away from the cement. If they do not break squarely, the tile is probably too weak or porous for use.

The agricultural engineering laboratory tests tile, clay or concrete, for any farmer, engineer, or dealer, sent to the laboratory, freight and express prepaid, with a letter giving the name of the sender and the manufacturer. Clay tile from some factories have shown an absorption as high as 27.5 per cent. Some concrete tile run as low as 3.2 per cent water absorption, thus making them very strong and serviceable while others from the same factory showed over 13 per cent absorption. When an owner is putting in a permanent improvement of this character, he should know definitely whether his tile are going to stand up or not. A few poor ones in a batch affect the value of the whole, because a line of tile is no better than its poorest member.

Brush Plow Improved by Staff Engineers

ONE OF THE big problems in upper Wisconsin is that of bringing the wild land under cultivation in the shortest possible time as well as at the lowest cost. For some years men have tried, by means of grub breaker and brush plows, to subdue areas where the stumps were few and well decayed and only the brush remained as an obstacle. A need of suitable equipment exists, however, which will adequately handle the breaking job on land overgrown with brush or filled with the roots and stumpage of brush that has been removed. In view of the fact that any method which will help to reduce the cost of putting this new land under cultivation must mean much to the state of Wisconsin and especially to the farmers in the northern counties, John Swenehart and F. W. Duffee (Agricultural Engineering) have continued their investigations of brush plows during the past year.

They find that the chief difficulty with brush-breaking plows has been that roots and brush accumulate under the beam and throw the plow out of the ground, thereby causing much waste of time, and a great deal of hard work must be undergone in order to free the plow from these obstacles. All of the plows as ordinarily designed have beams set directly above or slightly to the right of the landside, which readily causes the accumulation of trash against the beam to lift the plow out of the ground rather than being forced under with the furrow slice.

In order to obviate this difficulty some special castings were designed, which provide an offset for the beam to the left side of the plow. This reduces greatly the amount of brush, roots, and trash striking the plow and piling up under the beam. It permits the space directly in front of and above the plow to remain relatively free, and most of the brush is caught and turned under by the rolling action of the furrow

slice. A standing cutter, the upper end of which curves backward and to the right was also designed to further overcome the difficulty. This also aids in rolling the brush over and keeping it moving so that it is plowed under instead of accumulating on top.

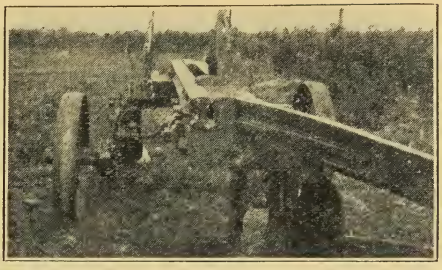
In trials conducted under extreme field conditions near Jump River, Taylor county, where poplar, willow, and tag alder brush were heavier than is ordinarily encountered it was found that such growth under 15 feet high did not cause trouble except when caught squarely on the point of the plow. Poplar trees as high as 30 feet caused trouble with the tractor. The soil was a dry silt loam with considerable stone, which caused trouble with the traction but seldom interfered with the plow. A 16-30 heavy wheel type tractor was used. Similar results were obtained at Merrill in comparison with other plows. A table of the data taken at Jump River follows:

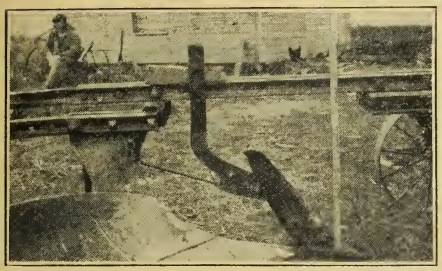
Plow	No. clogs per round	Time loss percentage	Job done
Sp. No. 3	2.5	10	Good
Standard No. 1	10.	48	Poor

Plow Special No. 3 was specially designed by the College staff. The right edge of the beam was 4.5 inches to the left edge of the land side and 8.5 inches offset from the original position. Clearance from the lower edge of the share to the lower edge of the beam was over 26 inches, which is approximately that of standard brush breaker plows. The width of the furrow was 20 inches, and a special cutter was used. The work of this plow was considerably superior to that of Standard No. 1, which is designed and sold by manufacturers for brushwork. With the specially designed plow there was a remarkable reduction in the number of clogs and the consequent time losses, and the resulting job was much more satisfactory. When clogging did occur, it was found that the accumulated material was removed more readily with the offset beam and wing cutter; in many cases necessitating only the backing up of the plow in order to give the accumulation a chance to be thrown out when the plow was again pulled forward.

Dynamometer tests with this outfit indicate that draw bar pulls of 2,500 to 3,000 pounds are frequent, and that pulls of over 4,000 pounds are often needed to pull the plows through cradle knolls and large brush stubble. This means that at least 8 good draft horses or equivalent pulling power would be required to handle an outfit. In case horses were employed, however, it might be necessary to remove the brush which a heavy tractor is able to knock down.

The plow and standard of the perfected machine are set to the right of the line of the original beam.





Clearance under the beam which is so important in preventing clogging has been increased in the perfected plow.

Clogging with the old type of plow was common, resulting in considerable loss of time.

A good job of turning under brush and small trees.

If the tractor can break down the second growth trees, they seldom interfere with the plow though they may be 15 to 30 feet high.

Marsh Plowing With Tractors

FOLLOWING the development of the marsh plow, some investigations and observations have been made regarding tractor sizes and lug equipment for this work by F. W. Duffee (Agricultural Engineering). The 20-inch plow, which is most commonly used for marsh plowing, usually requires a 12 to 15 horse power draw bar rating in the tractor. In practically all cases it was found that tractors weighing from 4,500 to 6,000 pounds operated most satisfactorily. The small light weight two-plow tractors frequently do good work with a 16-inch plow.

Where wheel tractors are used, the rear wheels should be at least 20 inches wide, and a 24-inch width is even better, especially if one wheel runs in the furrow. Angle iron lugs at least 3 inches and preferably 4 inches in width have been found most satisfactory. Several tractors equipped with spade lugs were tried out, but failed entirely; and, when the same machines were equipped with angle iron lugs, they operated very successfully.

It is sometimes necessary to equip the front wheels with extra extension rims; and, if the land is very boggy, a good clearance under the tractor is also required.

Worn Parts Greatly Increase Mower Draft

THAT a dull mower pulls harder than a sharp one is well known, but that the amount of increased draft is greater than has been supposed is shown by experimental work conducted by F. W. Duffee (Agricultural Engineering). The study has shown that a two-horse mower requires the power of three horses when it is extremely dull or when some of the cutting parts are badly worn; while two horses may pull such a machine, they are subjected to an undue strain.

A mower cuts like a pair of shears, and sharpening the cutting edges is only one-half of the problem, for in order to work properly the cutting parts, the section of the knife and the thin steel ledger plate of the guard, must be both sharp and fit together closely. The knife can be ground on the grindstone or emery, but the ledger plates, when worn, must be replaced. If the wearing plates which support the knife in the rear are worn so as to permit the points of the section to be raised from the ledger plate, poor cutting and heavy draft will result and the solution lies in replacing of the wearing plate.

In this work an old 5-foot mower was used, the cutting parts of which were worn so badly that it was about to be discarded though all the gears and bearings except those on the pitman were in good condition. The cost of putting this mower into first-class condition by repairs consisting of a new pitman, knife, guard, wearing plate, clips, and knife head was a little over $13. This shows that a small amount of money and a few hours of work will make a good smooth-running, clean-cutting mower out of the machine that was hard running and clogged so badly that it was about ready for the junk heap.

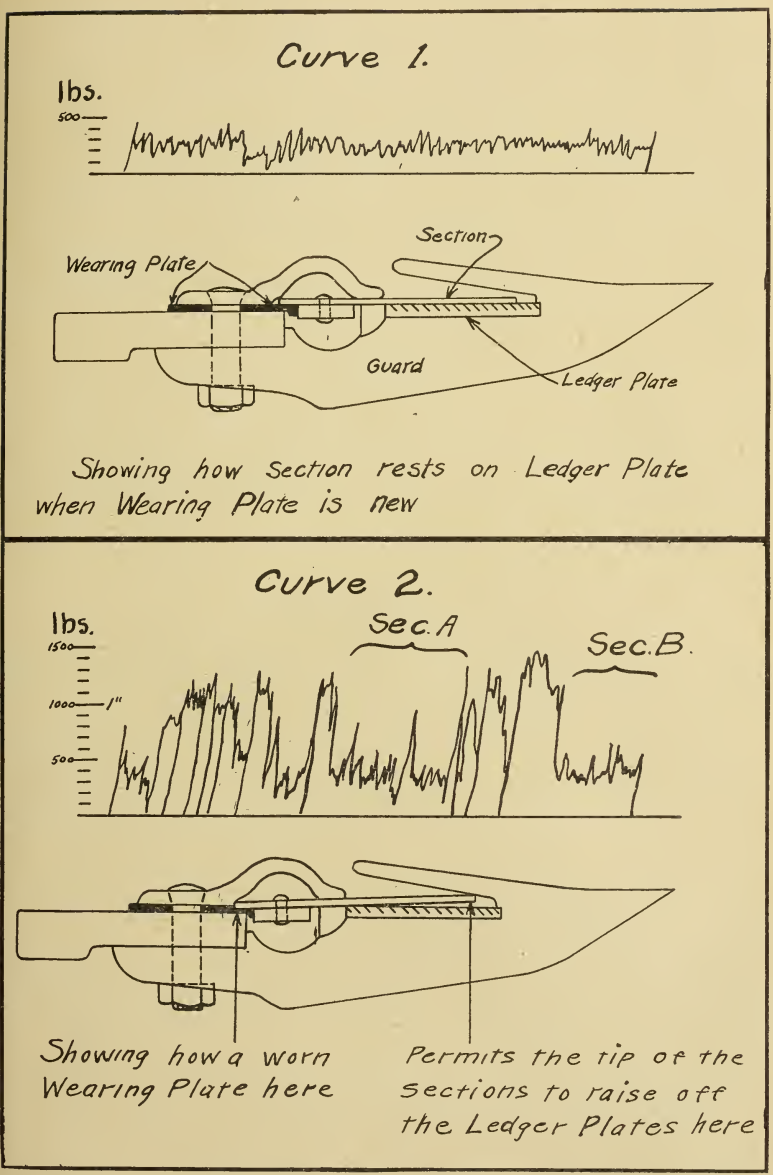


FIG. 53.—IT PAYS TO KEEP THE CUTTING PARTS OF A MOWER PROPERLY ADJUSTED

Many farm machines have in the past been junked when a few dollars invested in new parts would have added years to their service. The life of a mowing machine is in the cutting parts. Keeping them adjusted greatly increases smoothness of operation and length of usefulness. Curve 1 is smooth and shows the light steady pull of a sharp mower. Curve 2 shows that a worn mower is a heavy uneven puller and that the load may be 3 times as great as in a properly working machine.

The life of a mower lies largely in its cutter bar; and to keep it in order the following points should be observed:

1. Keep the knife sharp and the sections tight.
2. Keep sharp ledger plates in the guards.
3. Keep guards level by bending or shimming.
4. Replace the wearing plates when they become so worn that the tips of the sections no longer rest on the ledger plate.
5. Replace the knife head and knife head guide if the wear cannot be sufficiently taken up when they become worn.
6. Keep the clips hammered down just tight enough so as to eliminate play and avoid binding.
7. Sections should center at the extreme ends of the knife stroke with the tongue 30 inches from the ground.

PUBLICATIONS

The Experiment Station in 1921-1922 published 11 new popular bulletins and 3 reprints, and 2 new research bulletins. Thirteen new circulars and 9 reprints; also 14 new stencil bulletins were issued by the Extension Service.

The bulletins are listed below:

POPULAR BULLETINS

Bulletin 334.—Combat Potato Leafhopper with Bordeaux. (J. E. Dudley, Jr., and H. F Wilson.) History of the leafhopper and control of hopperburn by applications of bordeaux mixture.

Bulletin 335.—Judging Dairy Cattle. (G. C. Humphrey.) As successful dairymen are usually good judges of dairy cattle, it is important for all men to acquire this art.

Bulletin 336.—Farm Poultry Buildings. (J. G. Halpin, J. B. Hayes, and O. R. Zeasman.) Discussion of various kinds of poultry houses, with drawings of certain types.

Bulletin 337.—Tobacco in Wisconsin. (James Johnson and C. M. Slagg.) This bulletin treats of types, soils, and seed; as well as cultural, harvesting, and marketing methods.

Bulletin 338.—Winter Care of Bees in Wisconsin. (H. F. Wilson.) Loss of bees during wintering is the most serious problem among state beekeepers, but this can be prevented by proper temperature, good stores, and bees of correct age.

Bulletin 339.—New Pages in Farming. Annual Report of the Director 1920-1921. (H. L. Russell and F. B. Morrison.) A review of results secured on the different experimental projects conducted at the Experiment Station.

Bulletin 340.—Wisconsin Oats. (B. D. Leith and E. J. Delwiche.) As the leading grain crop in the state, the culture of oats deserves careful attention.

Bulletin 341.—The Use of Fertilizers on Dairy Farms. (A. R. Whitson and Griffith Richards.) A thorough discussion of fertilizers to be used in building up different types of soil.

Bulletin 342.—Milk—the Best Food. (H. Steenbock and E. B. Hart.) Milk, containing fat-soluble, water-soluble, and anti-scorbutic vitamines, is a perfect food, and should occupy an important place in the daily diet.

Bulletin 343.—Johne's Disease. (B. A. Beach and E. G. Hastings.) This disease, while not widespread in Wisconsin, will become more and more common, unless due consideration is given it by the cattle industry. The bulletin serves the purpose of bringing this disease to the attention of cattle men—both buyers and sellers.

Bulletin 344.—Better Cherry Yields. (R. H. Roberts.) Ways and means by which cherry yields can be increased.

RESEARCH BULLETINS

Research Bulletin 50.—Pump Drainage of the University of Wisconsin Marsh, (G. R. B. Elliott, E. R. Jones, and O. R. Zeasman.) A report of ten years' experience in the reclamation of a marsh lower than a lake immediately adjacent, by means of an electrically driven, automatically controlled pump.

Research Bulletin 51.—Rural Primary Groups. (J. H. Kolb.) A survey of Dane county of the first grouping beyond the family which has social significance and which is conscious of some local unity.

TECHNICAL ARTICLES

Much of the technical scientific output of the experiment station staff is first presented to the scientific public through the medium of the science periodicals and publications of scientific societies. The publication of such matter enables our workers to have their results scrutinized by their scientific colleagues. The following articles have been published during the past year, ending June 30, 1922:

Beach, B. A. Control of roup and chickenpox. Proc. Wis. Vet. Med. Assn. 37-42. 1922.

Beach, B. A., Hadley, F. B., and Piper, H. B. Tuberculosis in a shetland pony. Jour. Am. Vet. Med. Assn. 60:600-605. 1922.

Beach, B. A., and Hastings, E. G. Johne's disease and its detection. Jour. of Inf. Dis. 30:68-79. 1922.

Brunkow, O. R., Peterson, W. H., and Fred, E. B. The influence of certain factors upon the chemical composition of sauerkraut. Jour. Am. Chem. Society. 43: No. 10. 1921.

Bryan, O. C. Effect of different reactions on the growth and nodule formation of soy beans. Soil Science. 13:217-302. 1922.

Cole, L. J. The inbreeding problem in the light of recent experimentation. Proc. Am. Soc. Animal Prod. 30-32. 1922.

Dickson, J. G., and Johnson, A. G. Wheat scab and its control. U. S. D. A. Farmers' Bul. 1224. 1921.

Fluke, C. L. Syrphidae of Wisconsin. Transactions Wis. Acad. Sciences, Arts, and Letters. 20:215-253. 1922.

Fred, E. B., and Peterson, W. H. The production of pink sauerkraut by yeasts. Jour. Bact. 7:257. 1922.

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Hadley, F. B. Results from immunizing cattle against contagious abortion. Jour. Am. Vet. Med. Assn. 60:26-33. 1921.

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Hart, E. B., and Humphrey, G. C. Can home-grown rations supply proteins of adequate quality and quantity for high milk production? III. Jour. Biol. Chem. 48:305. 1921.

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Hastings, E. G. Constant temperature rooms. Jour. Indust. and Engin. Chem. 13:1056. 1921.

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Hillstrom, Ellen. The need for recognizing art principles in the teaching of home economics. Jour. Home Economics. 14: No. 2. 1922.

Hulce, R. S., Morrison, F. B., and Humphrey, G. C. Comparison of rations for dairy calves. Record of Proceedings of Annual Meeting of Am. Society Animal Production. 1922.

Humphrey, C. J., Johnson, A. G., and McKinney, H. H. Take-all of wheat and its control.. U. S. D. A. Farmers' Bul. 1226. 1921.

Johnson, A. G., and Dickson, J. G. Wheat scab and its control. U. S. D. A. Farmers' Bul. 1224. 1921.

Johnson, James. The relation of air temperature to certain plant disease. Phytopath. 11:446-458. 1921.

Johnson, James. Experimental evidence relating to the nature of the mosaic virus. Phytopath. (abstract) 22:26. 1922.

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(Jones, L. R., and Keitt, G. W.) Eugene Washburn Roark. The Septoria leaf spot of rubus. Phytopath. 11:328-333. 1921.

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Marlatt, A. L. Collegiate Training of Dietitians. Jour. Home Economics. 14: No. 2. 1922. Also in The Modern Hospital.

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Parker, F. W. The classification of soil moisture. Soil Science. 13:43-54. 1922.

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Wilson, H. F. Relation of climate to beekeeping manipulations. Jour. Econ. Ent. 15:143-146. 1922.

THE WISCONSIN AGRICULTURAL EXPERIMENT STATION, IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

1921-1922	Dr.	Cr.
To receipt from treasurer of the United States, as per appropriation for the year ending June 30, 1922, under the acts of Congress approved March 2, 1887, and March 16, 1906	$30,000.00	
By salaries		$17,285.77
By labor		5,953.85
By postage and stationery		22.61
By freight and express		2.85
By chemicals and laboratory supplies		752 10
By seeds, plants and sundry supplies		1,498.78
By fertilizers		194.03
By feeding stuffs		2,549.10
By tools, machinery and appliances		60.04
By furniture and fixtures		95.22
By scientific apparatus and specimens		1,383.20
By live stock		48.00
By traveling expenses		134.95
By contingent expenses		19.50
Total	$30,000.00	$30,000.00

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AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
STATIONS
MAIN
BRANCH
DEMONSTRATION
COUNTY REPRESENTATIVE

Bulletin 353 January, 1923

Farm Homes

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Plan the home to save the time and energy of the farm woman. Since the housewife spends most of her time in the home and has the task and responsibility of managing it, her needs should be most considered when planning a home. Page 3.

Screened working porches and living porches contribute greatly to the health of the farmer's wife and daughter. Page 4.

Running water in the farm home is essential. The burdens of the housewife are greatly lightened by running water in the home; and every member of the family will appreciate the comfort and convenience. Page 4.

A modified square house is economical to build and wastes the least space in hallways. The "Compact House" is a broad, low building, simple in construction and free from useless ornamentation. Page 4.

A square house built so that an extra half unit may be added is one of the most practical plans for a progressive farm home. The kitchen working areas are compact; the front and side entrances are both close to the kitchen; and all rooms are well ventilated. Pages 7-11.

The "Breakfast Alcove House" meets a very definite need of the farm woman who must make every moment count in the busy morning hours. The broken roof line is interesting and the house has the compactness of the more nearly square type. Pages 11-13.

A central hall extending from the front to the back of the house is a novel feature of the "Long Oblong House." The downstairs bedroom with wash room and shower attached are ideal for the farm home. Pages 13-16.

The "Hillside Cottage" enables the farm woman to do most of her work without climbing stairs. This cottage is planned for the hilly districts of Wisconsin. Pages 16-19.

In the "Colonial Farm House" the working areas of the laundry, kitchen, and dining room are very compactly arranged for saving time and energy. Pages 19-20.

The "Semi-Colonial House" combines the dignified, balanced exterior of the colonial house without the wasteful central hall. Page 24.

Farm Homes

Departments of Home Economics and Agricultural Engineering

FARM HOMES can be just as comfortable, convenient and attractive as city homes. Abundant space and plenty of fresh air and sunshine are much easier to obtain than in the city, and native trees and shrubs make attractive settings.

The modern farm home should be carefully planned and adapted to the needs of the family. A city house plan is often unsuited to a rural home because of certain differences between farm and city life. Housing farm workers, for instance, and the need for carrying on farm enterprises within the home make some arrangements essential in the farm house that would be unnecessary in the city.

Build Convenient Farm Homes

Plan the farm home to save the steps of the farm women. Careful planning may mean that instead of walking many miles a day to do her work, the housewife may accomplish the same results and walk only a short distance.

Avoid making any room a passage way to other rooms. Both heat and cleaning are saved in this way.

The main traveled paths in the farm home should be short and direct to save walking.

Every farm home should have a downstairs bedroom or office adjacent to the kitchen and the living room.

The kitchen should be the best ventilated room in the house. Moist heat causes exhaustion.

Farm workers should pass from the wash room directly into the dining room without going through the kitchen.

The dining room should be large enough to allow for the full spread of the table, room for the serving table, and passage way around the dining table.

If kitchen and living room are combined in one there should be a pantry connecting with it. Clean, sanitary food makes for health.

The door between kitchen and dining room should be wide enough for the passage of the "speechless housemaid" or wheel tray.

Bedrooms should all open into a common hall. Each person needs privacy some time in the 24 hours.

Each bedroom should have cross ventilation.

Screened sleeping porches will save doctor's bills.

Screened working porches and living porches are essential to the happiness of the farmer's wife and daughter.

The farm home laundry may have to be on the first floor.

The basement should be large enough for furnace room and storage room, but not large enough to be a dumping place for useless things.

Closets and cupboards are "first aids" in saving the strength of the farm housewife and should be liberally provided.

Running water in the farm home is essential; and electrical appliances mean longer life for the farm mother.

Trees, vines, and shrubbery pleasingly arranged will contribute much to the beauty of the farm home.

The Compact House (Fig. 1)

The compact house is a modification of the square house which is cheapest to build and wastes the least space in hallways. It is a broad, low building, simple in construction and free from useless ornamentations. A living porch and sleeping porch ex-

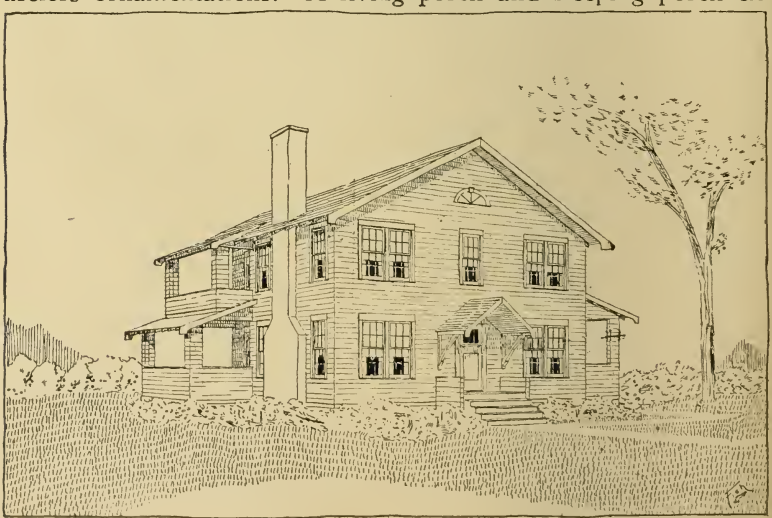


FIG. 1.—COMPACT HOUSE.

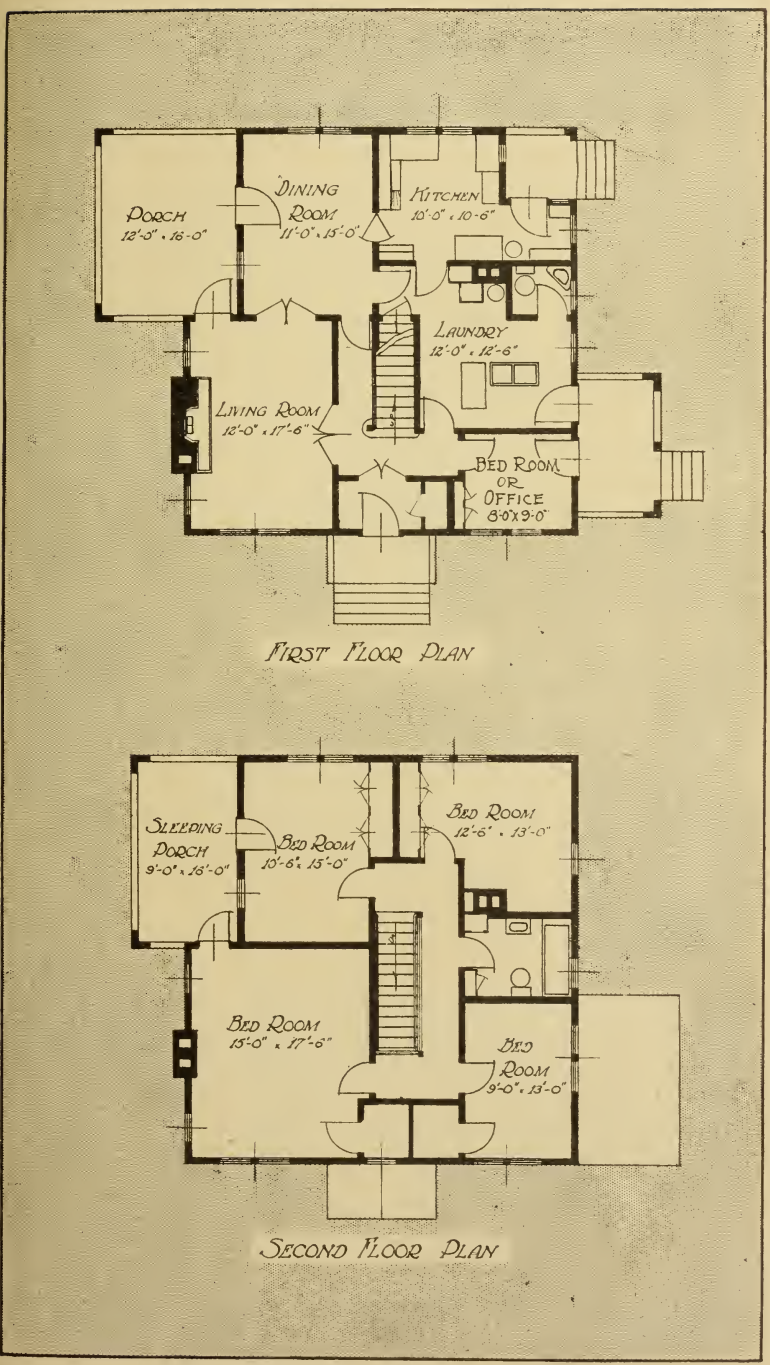


FIG. 2.—PLAN OF COMPACT HOUSE.

tend beyond the square of the basement, giving apparent width to the house. They are balanced by the chimney on the outside.

The house is entered through the vestibule, into which light comes from the upper half of the outer door and the glass doors opening into the main hall. The stairs rise near the center of the front half of the house and are therefore convenient to the living room and office and the side door which opens into the laundry. One may go upstairs from the kitchen or laundry without passing through the dining room or the living room. The cellar stair is under the front stair, opening into the laundry near the kitchen and convenient to the side door so that supplies may be carried to the basement without passing through the kitchen.

The first floor lavatory opens from the laundry and is below the bathroom on the second floor so that the plumbing is reduced to the smallest amount. (Fig. 2.)

The farm office may be entered from the outside, or through the laundry, or from the front hall without entering the living room. The dining room may be entered from the front hall or the laundry without going through the living room and the kitchen. A living porch opens from the dining room and the living room and is sufficiently large to be used as a summer dining room. The kitchen has a small screened work porch from which the ice box may be filled.

The working surfaces in the kitchen are arranged so that the worker moves from the sink and the work table to the range, to the serving table, to the dining room, and then back to the sink without crossing her path. Near the range is a wood box that may be filled from the kitchen porch without entering the kitchen.

The laundry is provided with two tubs, a stationary flat ironer, space for a water heater, range and a dumb waiter to the basement. The latter opens next to the kitchen door.

The second floor contains four bedrooms, sleeping porch, bathroom and linen closets. Each bedroom is provided with cross ventilation and has either a closet or a wardrobe.

A clothes chute leads from the bathroom to the laundry. If a furnace is not put in when the house is built, the two rooms on the second floor may be heated by stoves.

If an attic is desired, a third stairway leading to the attic can be built directly over the stairs leading from the first floor.

In an emergency, the office could be used as a sleeping room for a hired man.

The basement provides room for the furnace, coal, wood, fruit and vegetable storage, and a place for drying clothes in winter.

Because of the uncertainty as to the cost of building materials, no estimate of cost can be given. The house may be all wood, stone, brick, brick veneer or stucco.

The Unit-and-a-Half House (Fig. 3)

The unit-and-a-half house is intended to be built on the one unit plan with additions to be made later as the family grows. In its original form, it is a square house and may be built with a hip roof, or the gable roof (illustrated in the drawing of the completed house), which lends itself better to the addition of a half unit. The side elevation shows it in the one unit form.

The first floor plan (Fig. 4) shows the compact three-room house with entrance hall opening into the living room, back hall and kitchen. The side door opening from the ground level leads to the back hall, the basement and kitchen. There is a direct passage way through the back hall into the front hall so that the worker in the kitchen may reach the front door without going through the living rooms.

The back porch could be made wider than seven feet and screened in. A 9x12-foot porch is a very satisfactory working and even dining porch for the small family group.

The living room and dining room are connected by double doors so that they may be thrown together, making a larger space for entertainment, or they may be separated and the living room used in emergency as a temporary bedroom.

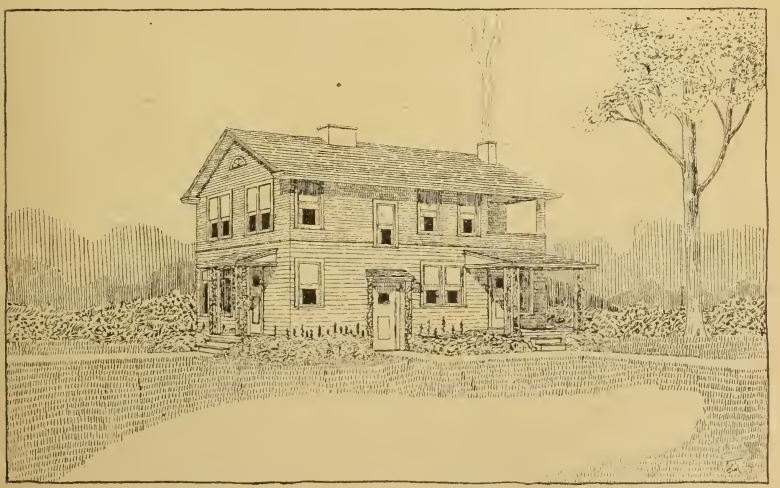
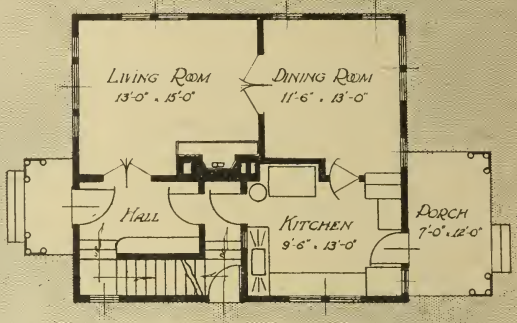
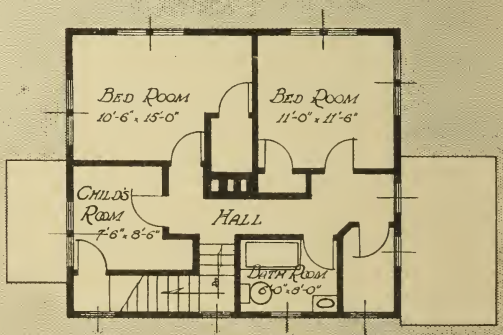


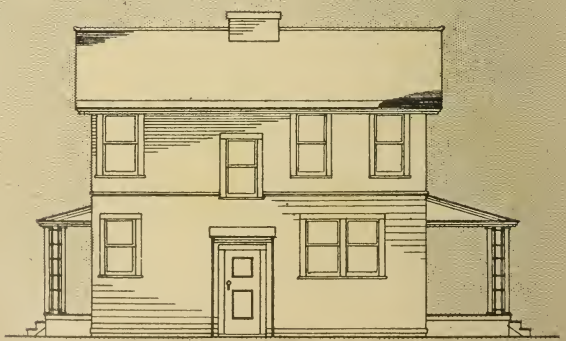
FIG. 3.—ONE UNIT HOUSE WITH HALF UNIT ADDED



FIRST FLOOR PLAN



SECOND FLOOR PLAN



RIGHT SIDE ELEVATION

FIG. 4.—PLAN FOR ONE UNIT HOUSE. (HALF UNIT TO BE ADDED.)

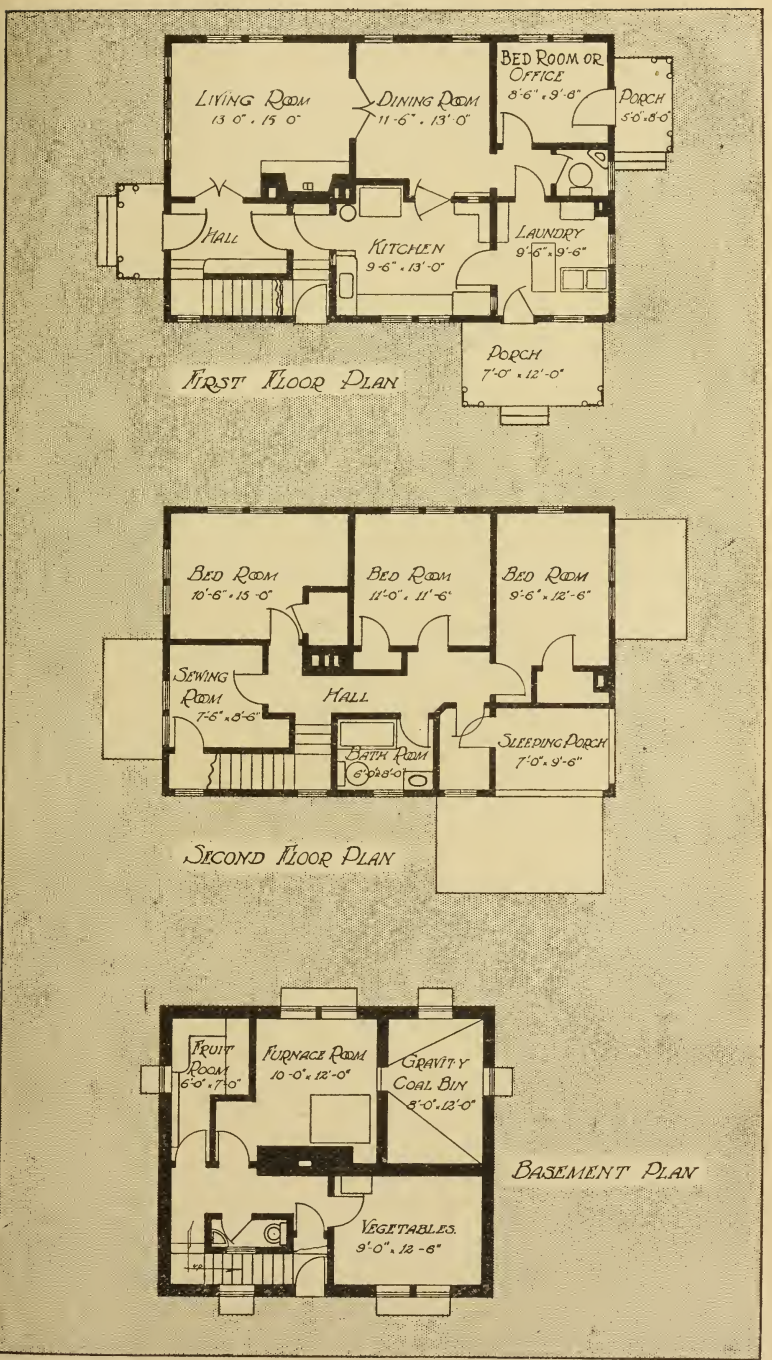


FIG. 5.—COMPLETED FLOOR PLAN FOR ONE-AND-A-HALF-UNIT HOUSE.

All bedrooms are provided with cross ventilation and with closet room.

The front stairs are convenient from the living room, the side door and the kitchen, so the second floor may be reached without going through other rooms.

The second floor is provided with two large bedrooms and one smaller room that in the beginning may be used as a child's room or nursery. When the house is enlarged this becomes a sewing room. There is a bathroom directly over the kitchen so that the cost of plumbing is small. The linen room next to the bathroom is a very well lighted room. Later, when the addition is put on, it becomes a dressing room for the sleeping porch.

A central chimney reduces the cost of construction and allows the house to be heated by either furnace or special stoves.

The basement (Fig. 5) is planned with a furnace room and a coal bin constructed with slanting sides so that as the coal is used it falls down to the opening, reducing labor to the minimum. The basement rooms are well ventilated. There is a lavatory in the basement, but this can be installed only when there is sufficient slope to the land to allow drainage. When this is true the vegetable storage room could be furnished as a laundry.

In the plans for the additional one-half unit the laundry will be adjacent to the kitchen and the kitchen porch will be placed at the side connecting the kitchen and the laundry as shown in the perspective (Fig. 3) as well as in the plan of the house (Fig. 5). The other additions on the first floor are the lavatory and the office. The office may be entered from its own porch or through the laundry or from the dining room. A small hall connecting the office and the laundry allows the field workers to use the wash room and come into the dining room without going through the kitchen.

On the second floor (Fig. 5) the addition includes a bedroom with its closet and a sleeping porch. The linen closet, which is shown in Fig. 4, now becomes a dressing room to the sleeping porch; and the child's room, shown in Fig. 4, becomes a sewing and linen room.

A third addition, not shown in the plans, but very strongly advised, is a large living porch opening out of the dining room and the living room. The door from the dining room onto the living porch would be in the space between the two windows and the entrance from the living room to the living porch could be through

the windows, which, in that case, would be made into glass doors opening on the screened and glazed porch.

With the addition of the living porch, the unit-and-a-half house would meet more nearly the needs of the progressive farm home than any of the other plans presented. First, the working

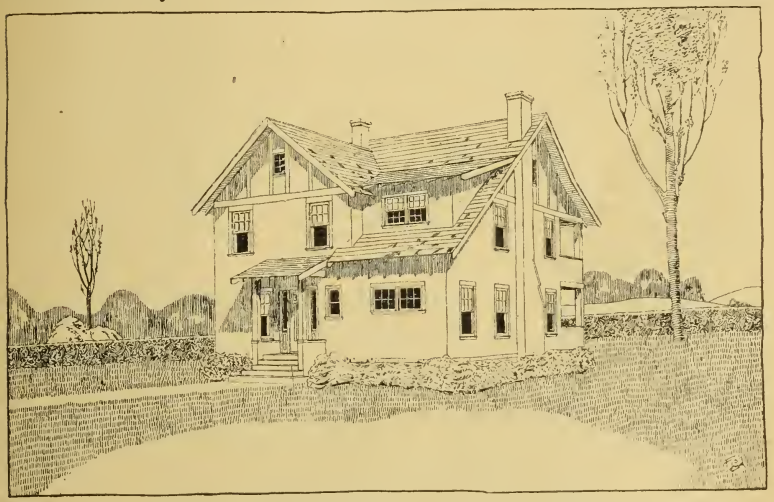


FIG. 6.—BREAKFAST ALCOVE HOUSE.

areas in the kitchen: ice box, working tables, sink, stoves and china closet are all planned to save space. The front entrance and the side entrance are both close to the kitchen. The laundry is well ventilated and the wash room is convenient to the dining room. There is a small compact basement and all rooms are provided with good ventilation.

The exterior of the house is in good proportion; the lines are simple and the cost of construction will not be excessive. It lends itself to clapboard construction, to clapboard and stucco, to English timber construction, and to clapboard and shingle. It may have an exterior finish of cement plaster.

The Breakfast Alcove House (Fig. 6)

The breakfast alcove house meets a very definite request from the farm woman who must make every moment count in her early morning hours. With the permission of the owner, it is adapted from a modern city house. The broken roof line gives a pleasing exterior while still maintaining the compactness of the more nearly square house.

The front entrance (Fig. 7) opens into the lighted vestibule which in turn opens into the central hall as well as into the break-

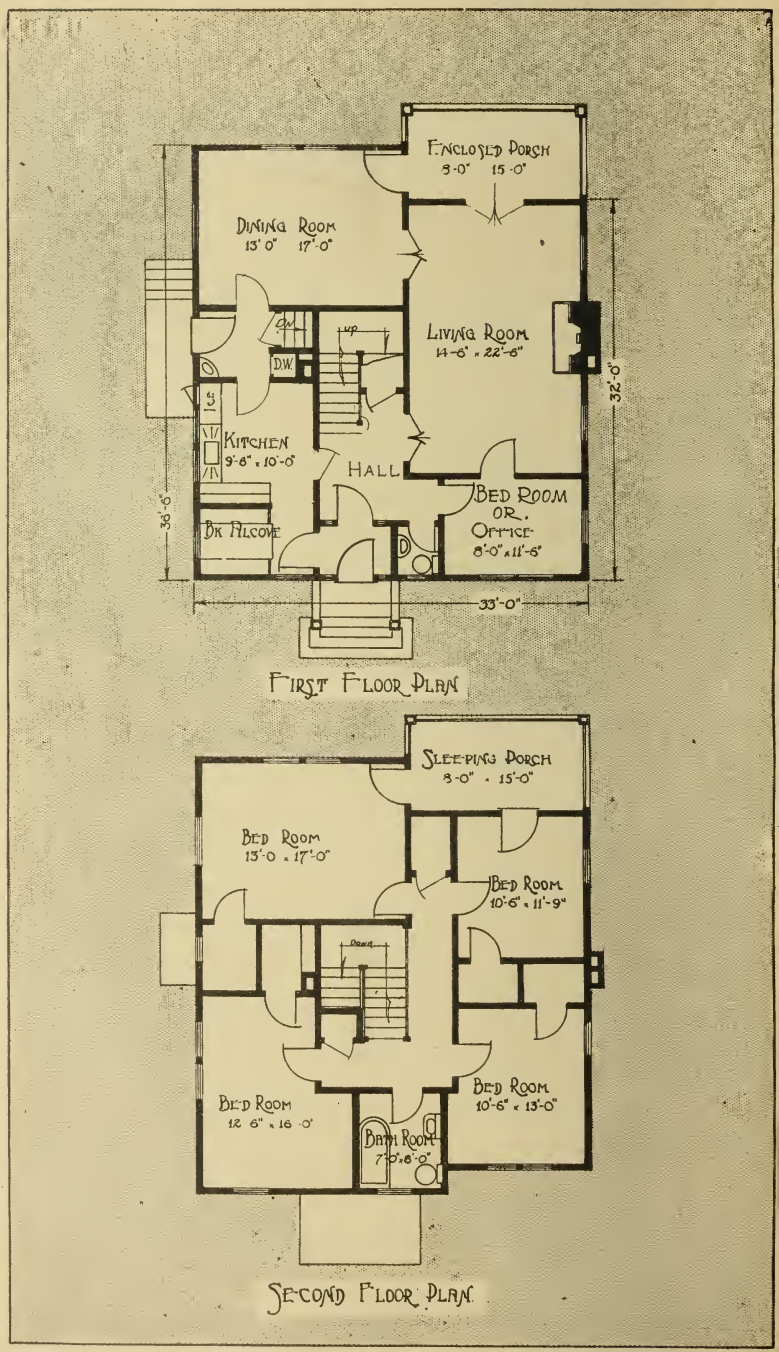


FIG. 7.—PLAN FOR BREAKFAST ALCOVE HOUSE.

fast alcove. This is and is not a part of the kitchen, being separated by the partition wall which forms the back of one of the settles. The alcove is not separated from the kitchen by a door. This allows cross ventilation in the kitchen and gives quick service in the breakfast alcove. The side door opens into the back hall which connects with the dining room on one side and the kitchen on the other and leads directly to the basement. In this hall there is a small wash bowl and the dumb waiter which leads to the basement. The hall space leads from the kitchen to the dining room, but does not increase the walking distance any more than if the area had been used as a pantry. The dumb waiter to the basement enables the worker to secure her supplies without carrying them up the cellar stairs. If a larger working porch is desired, the narrow entrance platform may be extended into a porch 9 feet wide which could be used as a dining porch.

The small lavatory and the office open out of the central hall; the main staircase leads from the central hall to the second floor and to the living room and the dining room. These and an enclosed living porch may form one general area, when desired, so that the house may be used as a community center. The office is large enough to be used for a small downstairs bedroom. Where there are small children this will be a great convenience.

The second floor contains four bedrooms, sleeping porch, bath, a linen closet and a storage closet. Each bedroom is provided with a large closet.

In this house it is planned to install a laundry in the basement, either in the corner under the breakfast alcove or directly under the office. The furnace room will be under the living room.

Low Oblong House (Fig. 8)

This house (Fig. 8) is planned with a central hall extending from front to back with the dining room, kitchen and living porch on one side and living room, bedroom or office and wash room on the other. The staircase begins at the center of the house leading to the second story. (Fig. 9). The basement stairs are directly underneath in very close connection with the back screened porch and the door opening into the kitchen. Adjacent to the screened porch is an outside entrance to the basement. The kitchen is provided with a built-in ice box which may be filled from the outside and is next to the built-in cupboard and counter shelf and the folding work table which may be built under the window. The sink is across the kitchen from the work table and

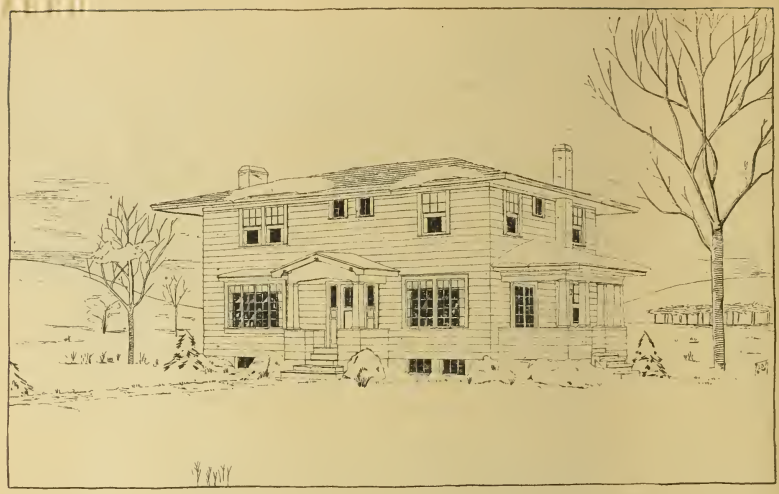


FIG. 8.—LOW OBLONG HOUSE.

is therefore not so convenient as in some of the other plans. With forethought the food and vegetables may be cleaned, carried to the work table and the preparation completed, the food cooked, served in the dining room and the soiled dishes carried out without crossing the main lines of travel. There is no connection between the china closet and the sink. It would be more convenient for the housewife if the china closet were built on the wall dividing the dining room from the kitchen and sliding doors arranged so that the soiled china could be put through to the sink table and clean china put back on the china cupboard shelves; but it would limit the length of the dining table.

The living porch opens from the dining room only. It would be much more usable if it were at least 9 feet wide, as 8 feet is too narrow for any but a very narrow dining table.

The living room, opening to the left of the hall, has a fireplace, book shelves, and a window seat. It is not directly connected with the dining room, so that for entertaining it is not so convenient as some of the other plans.

The downstairs bedroom or office with a wash room and shower are ideal for the farm house, as they permit all of the workers to use the wash room and office without going through either the kitchen or living room of the house to enter the dining room.

The hall space on the second floor has been reduced to as small a limit as possible, but is still liberal in area. The bathroom is over the washroom so that the cost of plumbing will

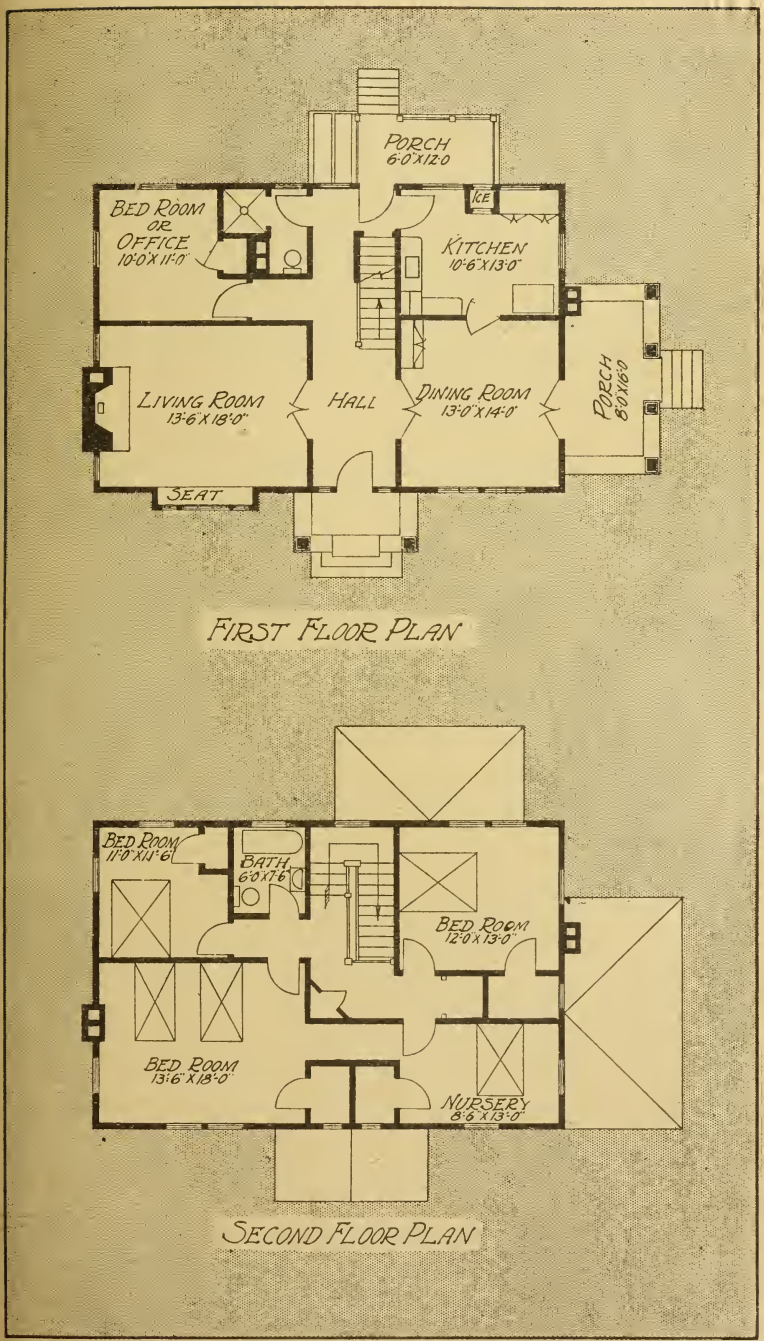


FIG. 9.—PLAN FOR LOW OBLONG HOUSE.

not be excessive. All bedrooms open into a common hall area and are provided with closets, three of which have windows. There is a linen closet and a bedding closet. The owner's bedroom is connected by a short passageway with the nursery. There are no doors between. The passageway is less than 3 feet wide and therefore a door between would be very narrow. If this space were utilized, one-half in the hall and one-half in the two closet areas with a door between the two closets, the same purpose would have been achieved; namely, the close connection between the bedroom and the nursery. The added hall space would be more nearly adequate for the movement of furniture and for better ventilation on the second floor, although every bedroom is provided with cross ventilation.

In its exterior finish, it is essentially a midwestern house with its oblong stretch and wide overhanging cornice. It may be finished in clapboard, siding, cement, or stucco, or it may be constructed of concrete.

The Hillside Cottage (Fig. 10)

This cottage is planned to meet the needs of the farm home in the hilly districts of Wisconsin. The large living porch at the front is balanced by the sleeping porch at the back. The first floor basement in the back has been planned to be used as the sleeping or living quarters of the men employed on the farm. Comparatively few farm homes are built so that the farm woman can do most of her work without climbing stairs. In this hillside cottage (Fig. 11) the large living porch is recessed under the main roof of the house and leads directly into the hall, on the right side of which is a large living room and on the left the dining room with its connecting passageway through the cellar stair hall to a small kitchen. In it the ice box, the kitchen table, and the range and cupboard form a sequence on two sides, and the dumb waiter, shelves and sink form a sequence on the opposite side from the range. There is sufficient floor space between but without any to spare. The work of preparing, cooking and serving the food follows in a direct path from the ice box around the room to the dining room.

There is a direct connection from the side porch downstairs to the basement. The dumb waiter connects directly with the basement, is near the vegetable room, and saves all the work of heavy carrying.

The bathroom is close to the kitchen so that the plumbing

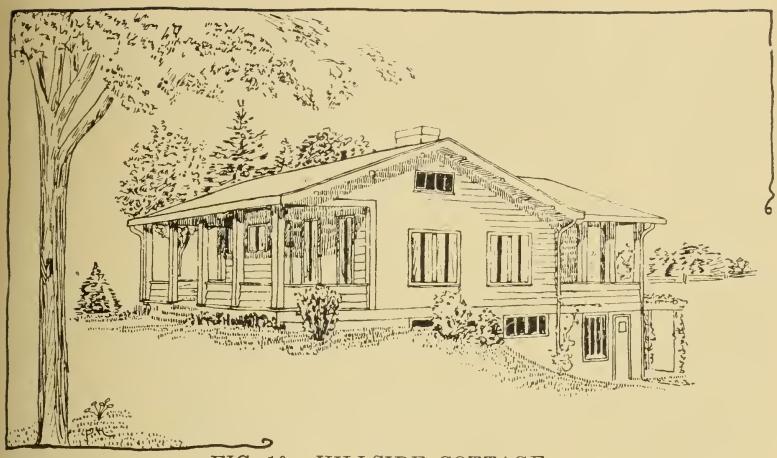


FIG. 10.—HILLSIDE COTTAGE.

cost is small. It is planned that the range will be either a gas or oil burner, rather than coal or wood, as the house is heated with hot-water heat.

There are three bedrooms and a sleeping porch with a closet or wardrobe in each of the bedrooms. The owner's bedroom is provided with a fireplace. The chimney stack contains flues for the fireplace, the furnace, and the laundry stove.

The basement at the back is all above the ground level. Under the dining room, kitchen, living room and first floor bedroom are a vegetable room, trunk room, laundry, furnace room and coal and ash areas. Back of these, connecting with them by a door, is a bedroom and bath and a main living room. These open on a paved pergola which should be vine clad.

This hillside type of cottage, because it contains all of the living and sleeping areas for the family on one floor, reduces the work of the farm woman. It is especially desirable when there are small children in the family, because the bedrooms and sleeping porch may be reached in a moment. Where farm hands are not employed, the basement living area could be used as a milk room and garage.

The Colonial Farm House (Fig. 12)

The colonial farm home is typical with the white clapboard, green blinds, and lattice for roses. It has a wide central hall with the stairs starting well to the center and leading to the second story with a landing two-thirds of the way up, thus giving room for the back hall underneath the landing.

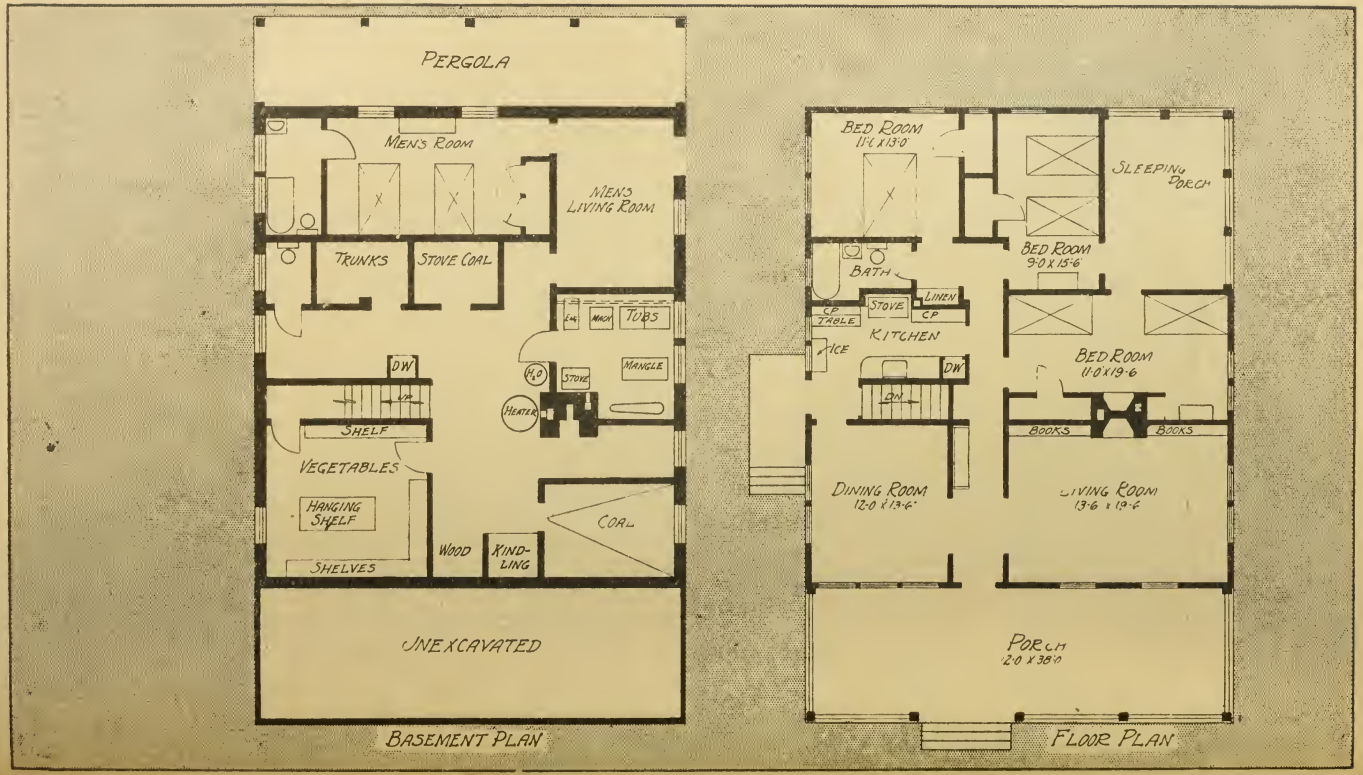


FIG. 11.—PLAN FOR HILLSIDE COTTAGE.

The cellar stairs open from the back hall and are underneath the stairs to the second floor. The entrance to the kitchen is from the front hall, from the back hall, and the service porch. The laundry is back of the kitchen and uses the same flue stack. The working areas of the laundry, kitchen, and dining room are very compactly arranged for saving time and energy.

The relation of the laundry and wash room to the dining room makes it possible for field workers to come to the dining room without passing through the kitchen.

The front vestibule protects the hall from the change of temperature in the winter and allows the hall to be connected by open doors with the dining room and living room without unnecessarily cooling the house. The living room is provided with bookcases and built-in seats as well as a fireplace. It is a large room with a glazed door opening onto a large living porch.

The second floor (Fig. 13) contains four bedrooms and a bath. If desired, a screened sleeping porch could be built over the living porch without seriously modifying the architectural design of the house, though it could be used as an open-air uncovered sleeping porch as it is.

There is a minimum of waste hall space in the second story and the bedrooms are all large and well ventilated.

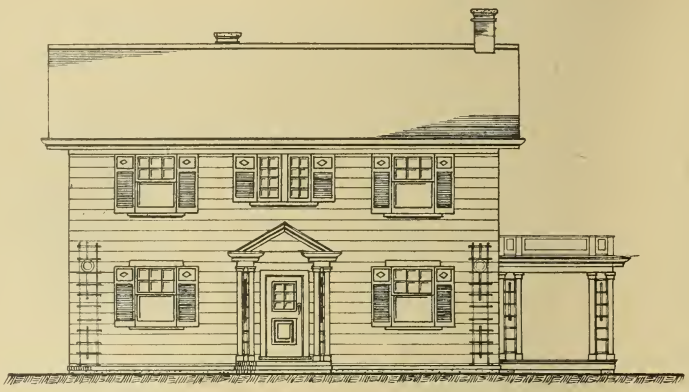
The basement contains furnace room, wood and coal area, fruit and vegetable storage room, and general utility room reached from the back entrance without going through any other part of the first floor.

The basement is lighted through recessed window areas covered with iron grating. The house is intended to be built of wood, but it may be built of stone, brick, or hollow tile and stucco. It is an expensive house, but represents the ideal colonial design for farm homes, excellent in proportion, simple in construction, and free from ornate ornamentation.

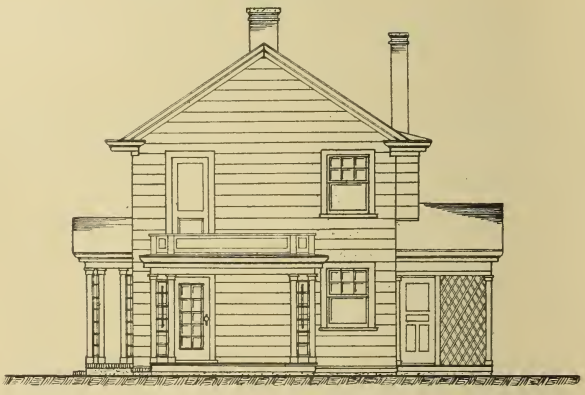
The Semi-Colonial House (Fig. 14)

This house combines the dignified balanced exterior of the colonial house without the wasteful central hall extending from the front door to the back door.

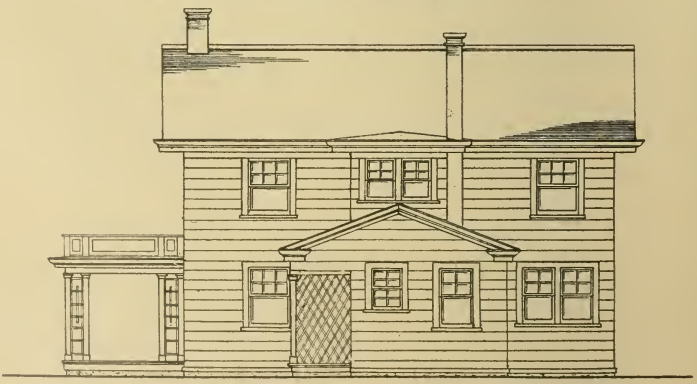
The hall is L-shaped and the stair-well is the center of the house, thus saving space in grouping. The hall is close to the side entrance and the stairs, the office, basement entrance, lavatory, laundry, and kitchen. (Fig. 15.) The stairs are open for



FRONT ELEVATION



RIGHT SIDE ELEVATION

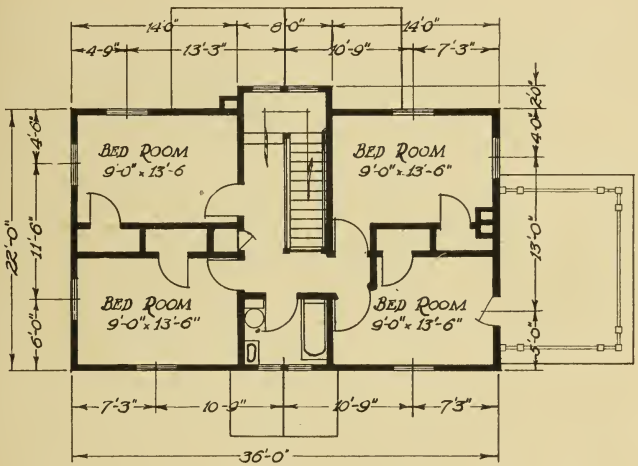


REAR ELEVATION

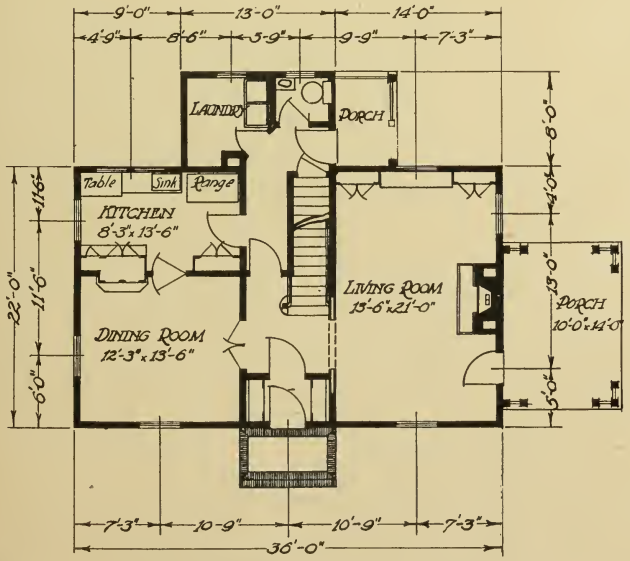
H-5-21

FIG. 12.—COLONIAL FARM HOUSE.

Original design by the state architect. Revision by the department of Agricultural Engineering to meet farm conditions.



SECOND FLOOR PLAN



FIRST FLOOR PLAN

H-5-22.

FIG. 13.—PLAN FOR COLONIAL FARM HOUSE.

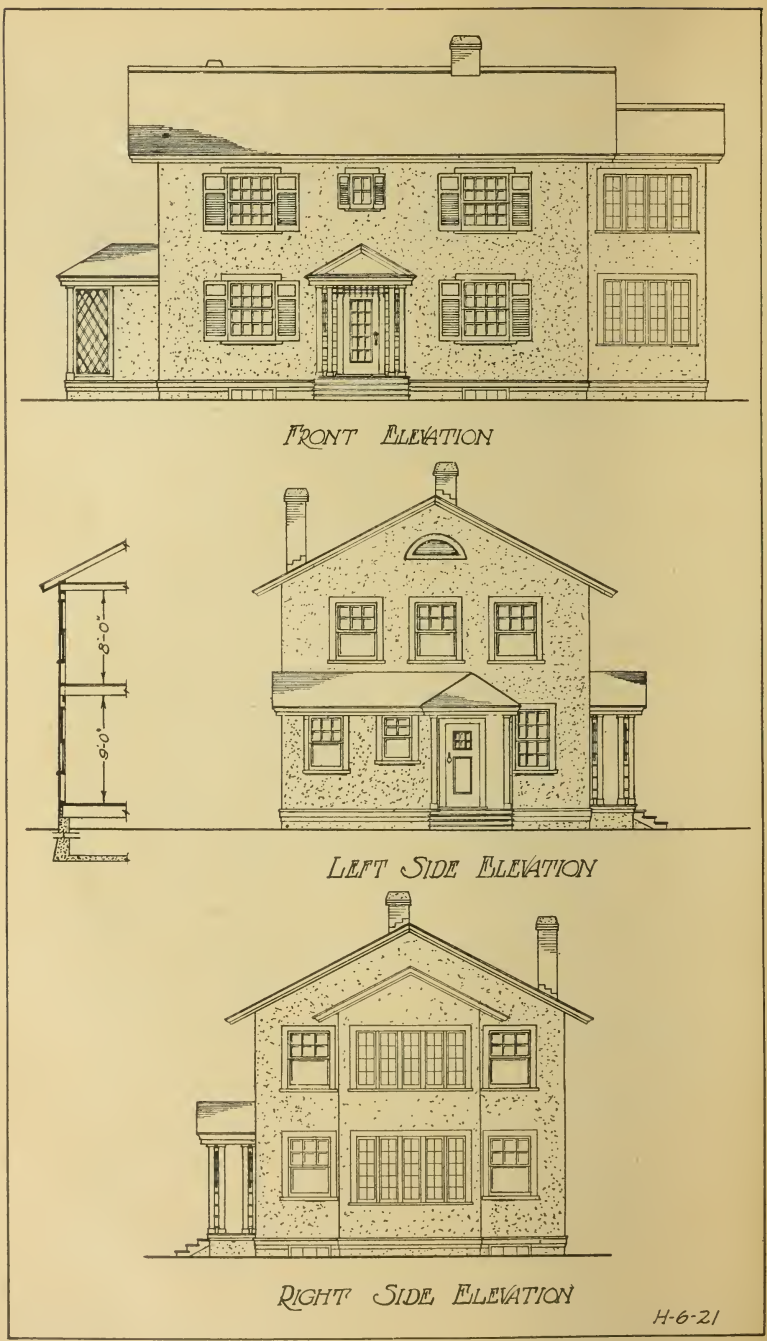
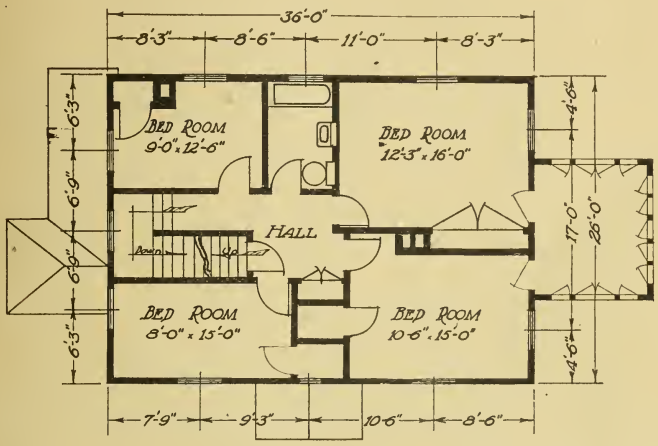
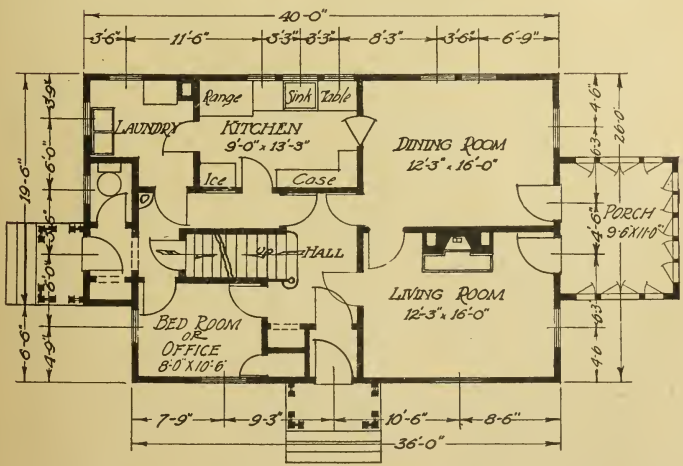


FIG. 14.—SEMI-COLONIAL FARM HOUSE.



SECOND FLOOR PLAN



FIRST FLOOR PLAN

H-6-22

FIG. 15.—PLAN FOR SEMI-COLONIAL FARM HOUSE.

four steps so that the effect is one of space and dignity even though the stairs are enclosed beyond the fourth tread.

The living room opens from the central hall and is connected by single doors with the dining room and the living-dining porch. The fireplace is on the inner wall, thus saving heat. The living porch is glazed and during the fall and spring may be a living porch, warmed from the house. In summer, screens are to be added.

The dining room is connected by a swinging door with the kitchen and by a door with the central hall so that the men may enter from the side door or office without passing through the living room or the kitchen.

The kitchen, placed in the center between the dining room and the laundry, is well lighted with three windows. Cross ventilation is provided by doors into the laundry and into the side hall. The flues for the range in the kitchen and the laundry are in the same chimney stack. This places the range far away from the dining room and lessens the possibility of odors passing easily. The ice box may be filled from the hall.

The laundry room may be used as a dairy room if that seems desirable, otherwise it is a laundry and coat room.

The office may be entered from the front door or from the side door. There is a small closet in it so that it could be used as a sleeping room in emergency.

The second floor provides for four well-ventilated bedrooms, two of which are connected with a glazed and screened sleeping porch.

The hall space is small and compact. Each bedroom has a closet or wardrobe. The bathroom is over the kitchen so that the cost of plumbing is reduced. There is a small linen closet and large dark attic space for storage. This attic is reached by a stairway over the one leading from the first floor to the second.

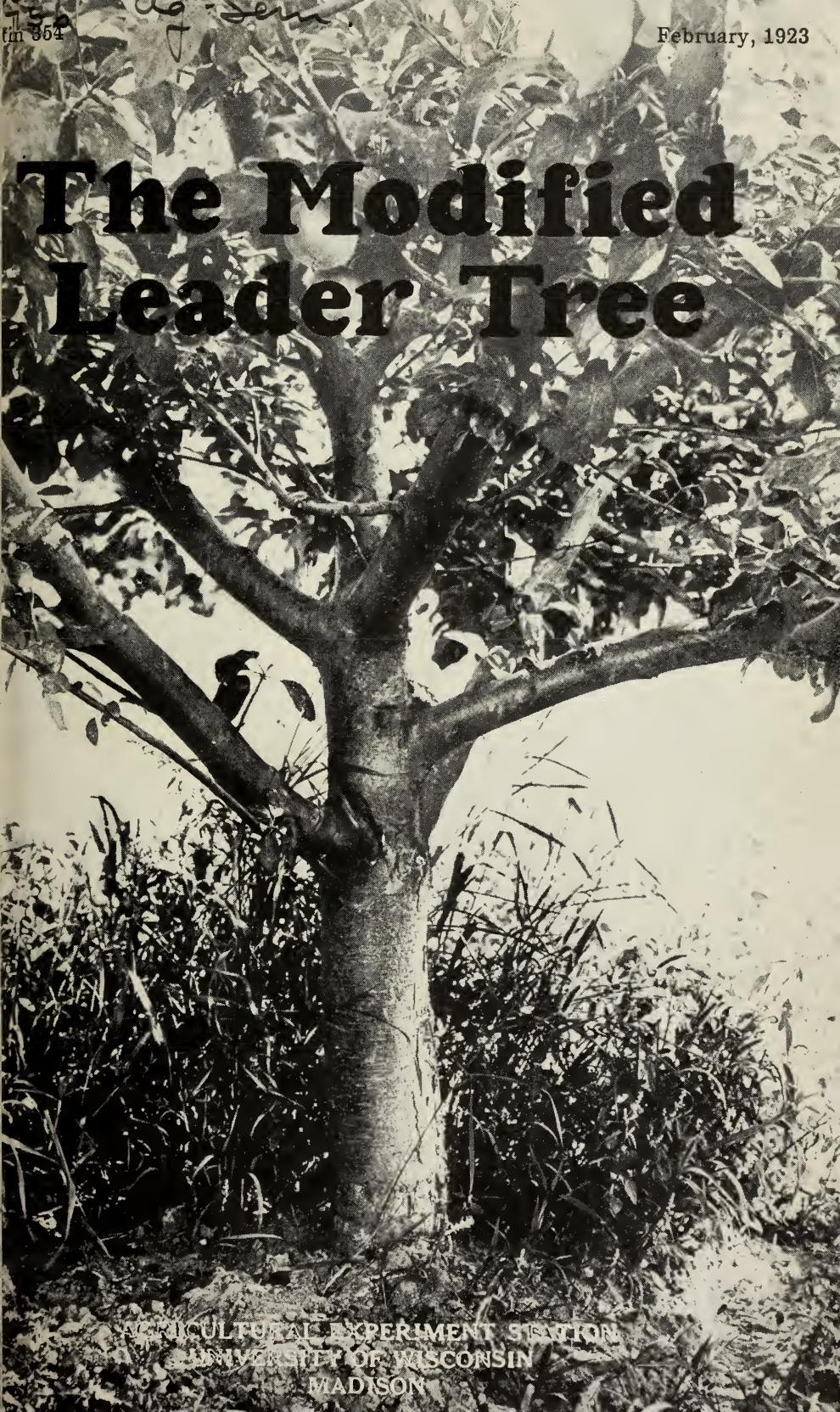
The basement should be arranged for a furnace room, and coal bins under the dining room, a work room under the living room, and a vegetable cellar and fruit room under the kitchen and office.

It is plentifully provided with basement windows so that the area will be light. The cellar stairs are conveniently arranged so that they end in the center of the basement.

Bull 354

February, 1923

The Modified Leader Tree



AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

The modified leader tree is better than either the central leader or open center types. It bears better crops of fruit. It is not a "double deck" tree. Page 3

Plant one-year-old nursery trees. They usually grow better, and this should mean better fruiting. Page 5

Prune the tree at planting time. Reduce the top in proportion to the root pruning done when digging. Page 7

Start to form the tree-head the first year. This avoids much trouble in later years. Page 8

Avoid weak crotches by unequal heading of branches. Keep the branches balanced-up by proper heading back. Page 10

The two-year tree should be carefully pruned. Properly pruned trees start to spread at this age. Page 19

Tall narrow trees can be prevented. Careful attention in the third and fourth seasons may prevent excess height and density of top. Page 21

Open center trees can be changed into modified leader trees. This should not be attempted after the third to fourth year. Page 26

Wind-bent trees may be straightened up. Prune lighter on the windward side. Page 27

Avoid heavy cutting after the fourth year. This tends to delay fruiting. Page 27

Dense topped trees are late in bearing. A certain type of early summer pruning may help this trouble. Page 28

The Modified Leader Tree

R. H. Roberts

THE MODIFIED leader tree has been very largely adopted. Its superior advantages, however, justify its much wider use for apples, pears, and cherries and possibly for plums and peaches.[1] Some of the advantages of this tree are: Freedom

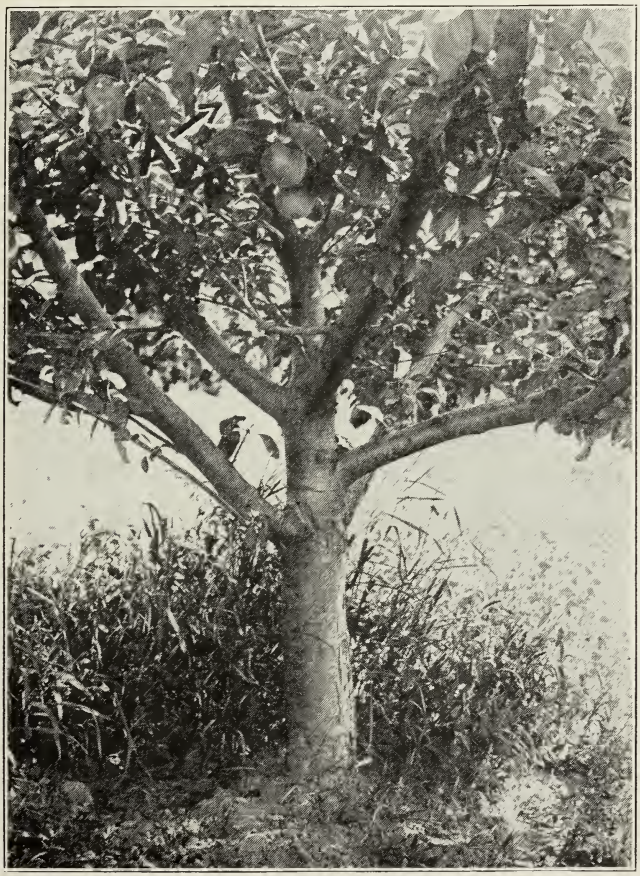


FIG. 1.—WELL BALANCED MODIFIED LEADER TREES HAVE STRONG HEADS

The spacing of the branches of this tree is not very good. Use of the leader has, however, produced a strong head. The leader "A" has been developed into the upper main branch. The head is shorter than usual, but a good tree resulted, Fig. 27. Note the uniform size of the main branches. This is essential to producing a uniformly vegetative top. Compare with Fig. 28. McIntosh.

[1] In this case the head would be kept low and relatively short, the leader being used to help distribute the main branches and if possible to avoid bracing and propping such as is required for old open center peach trees.

from weak crotches such as occur in the open center tree; a lower and more spreading tree than the central leader type; a large number of main branches giving a top in which the branches grow uniformly; and a better fruiting system than in either of the other types of trees.

There is much misunderstanding or difference of opinion as to what constitutes the modified leader tree. There are at least three common erroneous ideas: It is not a "double-deck" or "two-story" tree, neither is it a "central leader tree" with the center cut out "after two or three years." In fact, the modified leader tree is in no way a central leader tree.

The young modified leader tree is rather a tree with a central or tip branch left in but cut back so as to be only *slightly longer* than the lateral or side branches. The laterals are kept well balanced with the leader (Fig. 1) and a low, spreading tree is produced (Fig. 2) as contrasted with the tall, narrow central leader tree (Fig. 3) or even the tall but medium-wide

FIG. 2.—TREES WITH MANY WELL-BALANCED BRANCHES ARE LOWER AND MORE SPREADING

This tree has no strongly dominant leader. The lower branches are relatively large because not overgrown by a strong leader. This combination gives a very desirable low, open-topped, spreading type of tree. The sparse foliage is due to autumn leaf fall having begun. This tree was headed high originally, but started with several main branches. Compare with Fig. 3. Grimes Golden.

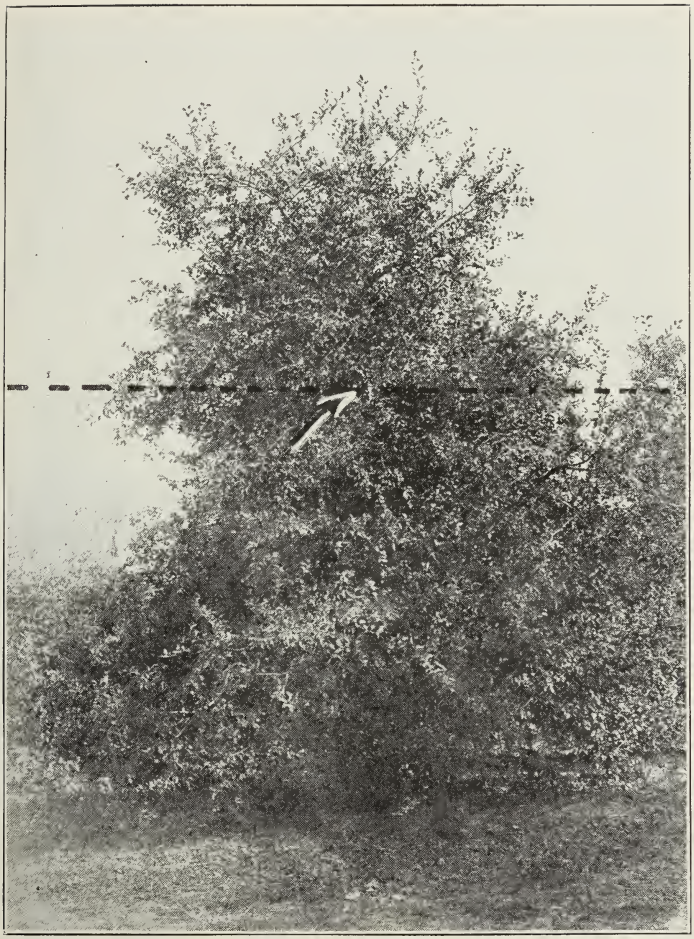


FIG. 3.—LEADER TREES GROW TOO TALL

This necessitates extra harvesting expense and multiplies spraying difficulties, apparently without adding fruiting surface. Wood produced above the dotted line is at the expense of lower branches. Note the dominant leader at this height. Compare with Fig. 2. Winesap.

open center tree (Fig. 4). After a sufficient number of main or so-called scaffold branches have been developed the leader is developed as the highest one of the main branches.

Plant One-Year-Old Trees

The first step in growing a modified leader apple tree is to plant a one-year-old nursery tree. In the first place this tree can be headed at the desired height. It is preferable to have the lowest branch start from 24 to 26 inches from the ground. As

FIG. 4.—OPEN CENTER TREES USUALLY GROW OVER-TALL

The so-called open center tree with few main branches usually develops into a tree with two or three dominant leaders, (A). These soon outgrow the lower branches, (B). The latter very frequently become overgrown and "run out" before the tree comes to full bearing. Jonathan.

the average tree produces branches from but three to four buds immediately below a cut (Fig. 18) the tree should be headed back five to six inches above the height preferred for the lowest branches. Heading the trees at 28 to 33 inches at planting time is suggested. The reason for this height is to secure lateral branches with good angles and proper spread (Fig. 5). If the branches are too low, bad crotches are formed. If they are too

high, they turn down in a few seasons due to shading of the higher branches and then interfere with cultural operations. When started at two to two and one-half feet, light conditions are better at the side and above than below the branch so it, consequently, maintains a permanently upward direction.

A second reason for planting one-year-old trees is that this gives a tree which is capable of making a strong growth. That is, a tree may be a "slow grower" if it did not get large enough in the nursery to sell after one season. Of course, not all two-year-old nursery trees are too small to sell the first year. What is wanted for orchard planting is, however, a tree with the *capacity* of growing vigorously and fruiting profitably. A tree which is large enough to sell as a yearling should be more apt to do this than a smaller yearling, or a two-year tree grown from a small yearling.

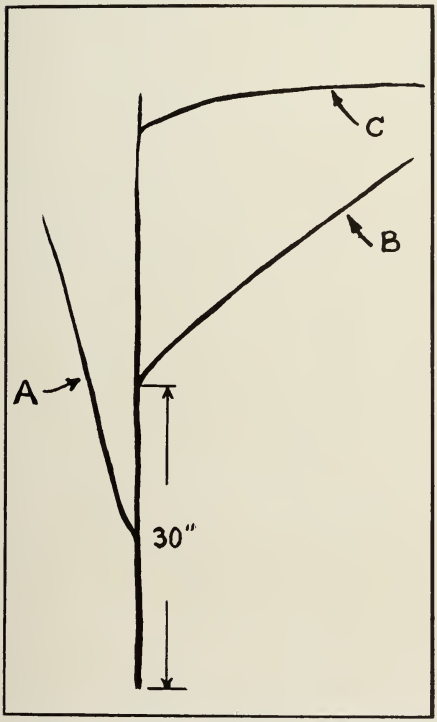


FIG. 5. — THE LOWEST BRANCH SHOULD BE ABOUT TWO FEET FROM THE GROUND

Very low branches (A) generally form bad angles with the trunk. High branches (C) grow too nearly horizontal where there are no branches lower down on the trunk. Branches arising from two to two and a half feet from the ground usually form good angles with the trunk and also maintain an upright position (B). See Fig. 1.

It is incorrect that planting older trees gives more productive trees than planting yearlings. If so, it would be better to plant three- or four-year-old trees. What is wanted is a tree that will stand transplanting well. From this standpoint the yearling is to be preferred over the two-year tree.[2]

The third reason for choosing a one-year-old tree is that it usually starts better than the two-year-old. The latter is too

[2] It is possible that two-year-old nursery trees transplant better in more southern latitudes where fall planting is practiced.

apt to merely "feather out" and make practically no growth the first year unless it is pruned very heavily (Figs. 6-7). If heavy cutting is done the gain in size over a yearling is lost. In case it is necessary to plant two-year-old trees they should really be cut heavily to reduce the top in proportion to the reduction in root made at digging time. If trees with very low heads are secured, it is often better to "whip" them (Fig. 8). Trees treated in this way can be expected to make a good growth the first season after planting, whereas two-year-old trees which are pruned little at planting time rarely start well, especially in northern latitudes. Also, two-year trees are frequently poorly branched, both as to number and spacing.

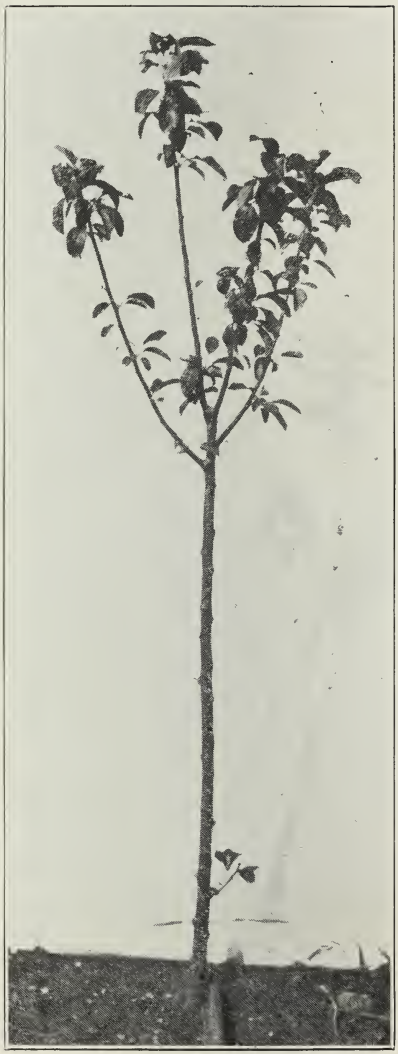


FIG. 6.—TWO-YEAR NURSERY TREES DO NOT USUALLY START WELL.

It is usual for two-year trees to merely "feather out" the first season after planting. Fameuse.

Prune Carefully the First Year After Planting

Success in forming an orchard tree depends largely upon the treatment given it the first few seasons after planting. This is apparent from some of the objects to be gained by pruning at this time. These are:

FIG. 7.—TWO-YEAR NURSERY TREES DO NOT USUALLY BRANCH WELL

In cases where the two-year trees do make a good growth there are generally too few branches. When heading back (at arrow) a high lateral branched tree is secured. Compare with Fig. 8. Fameuse.

FIG. 8.—TWO-YEAR TREES USUALLY GROW WELL AFTER BEING "WHIPPED" AT PLANTING

It seems best to whip two-year trees at planting time if they are low headed enough (A). The top branch is used as trunk (E). When pruning the next season, the upper branches are headed back heavily (B), to keep them in balance with the lower ones (C). The smaller low branches (D) will rarely become main limbs of the tree. Fameuse.

FIG. 9.—"COMPETING" BRANCHES THICKEN UP IN RELATION TO THEIR LENGTH

Note how the two-year-old branches have thickened up in proportion to their length at the beginning of the growing season (at arrows). The longer branches made the most growth. Apparently the greater foliage on this growth results in a greater diameter of the two-year-old wood. This fact or principle of growth is used to avoid weak crotches in trees by heading back competing branches unequally. Fig. 12.

1. Keeping the top balanced;
2. Preventing excess height of top, and
3. Increasing the number of main branches.

Balancing of the top is the most important reason for pruning the yearling orchard tree.[3] This is excuse enough, however, at this time. It cannot be said, as was formerly thought, that pruning induces fruitfulness of young trees. Many trees would bear earlier if they were left unpruned. An exception to this general rule is in the case of very vegetative, dense-topped trees, as young Transparent. Such trees seem to bear earlier if pruned to admit light than if left unpruned (page 28). The greater necessity for pruning the young trees lies, however, in the need for keeping the branches in balance. The object in doing this is to develop a uniformly vegetative, and so, a uniformly fruitful top and to prevent weak crotches.

These objects are accomplished by the use of the following principle of growth: "Competing" branches (those which

[3] The number of years after planting in the orchard is meant when speaking of the tree as one, two, three or four years old.

FIG. 10.—LEAVING THE LEADER TOO LONG GIVES A "TWO-STORY" TREE

When the leader (A) is left too much longer than the laterals (B), the latter become dwarfed. The upper set of laterals (C) soon outgrow the lower ones and the tree head really begins at A. McIntosh.

arise from near the same place) *will make an unequal growth if they are of unequal length* (Fig. 9). Likewise, they will make an equal growth (in diameter) if they are of the same length.

It follows, then, that the size of branches can be largely regulated and bad crotches can be almost entirely prevented by unequal heading back. The important point is knowing the proper relation to be maintained between the branches. A common error is to leave the leader too much longer than the laterals. (Fig. 10). This results in the undesirable "two-story" type of tree.

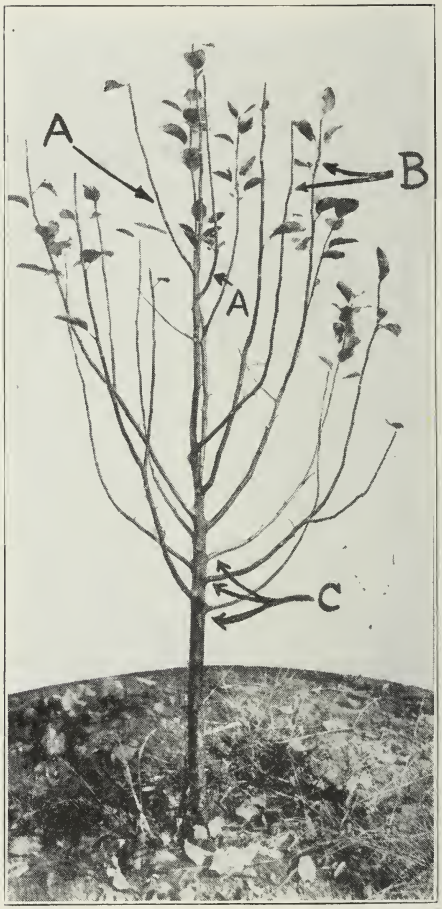


FIG. 11.—PRUNE THE TWO-YEAR TREE CAREFULLY

New main branches (A,A) are developed from the leader. Growths over 20 inches long (in most varieties) are headed back (Fig. 18). Keep the leader only slightly longer than the other main branches. This tree may have too many branches for some varieties. Being a Transparent it cannot be kept very open or suckering results. Note the spreading habit as in Fig. 22. Summer tipping was done (B) with no apparent benefits.

The trouble with this tree is that the upper set of branches outgrows the lower one, necessitating the eventual removal of the latter even before the tree comes to bearing age. If the leader is kept in proper balance it is possible to develop new branches in continuous succession and not in sets (Fig. 11).

Leave the Leader Slightly Longer Than Laterals

The central branch gains considerable dominance over the laterals because of its position. Consequently the relatively small difference of two to three inches *in length* is enough to maintain it as a leader. The top branch is one to three inches higher up on the trunk than the laterals. We recommend then, to cut back the leader at a *height* of three to six inches above the level of the cuts on the laterals (Fig. 12). This recommendation can not become a rule, however, for the reason that the

FIG. 12.—KEEP THE LEADER ONLY SLIGHTLY LONGER THAN THE MAIN BRANCHES

The yearling nursery tree usually starts well. This one was headed a little too high. Lower branches as B and C cannot usually compete successfully with the upper ones so they cannot be depended upon to become main branches. Prune as indicated by arrows when dormant. Winter Banana.

FIG. 13.—STRONG LEADERS SHOULD BE CUT BACK HEAVILY

In cases where the leader is much stronger than the laterals it should be cut back shorter (B) than if the branches are well balanced (A) as in Fig. 12. Wealthy.

branches are sometimes not in balance at the end of the growing season (Figs. 13-17). A weak branch should be left relatively longer while a very strong growth should be cut back somewhat heavier than if it were well balanced with the other limbs. For this same reason the lower branches are often cut at a greater *length* than those higher up. It is desired that all grow about alike. The upper branches have the advantage (at least they grow better) so the lower ones are left longer (actual length of branch).

The question arises now as to what length the branches of the yearling orchard tree should be headed back. For ordinary varieties we suggest that 18 to 20 inches is about the proper length. The reasons for selecting this length are:

1. If the branches are left much longer they become long and "leggy" without becoming well spurred (Fig. 18).
2. If the branches are cut back much shorter than 18 to 20 inches the tree top does not have sufficient circumference

to give space to allow for increasing the number of branches (Figs. 19, 20).

3. The best spur fruiting systems are secured when heading is done at about this length.

The tipping or heading back which is done to balance the branches gives the other two results to be gained from pruning the yearling tree: excess height is avoided and the number of branches is increased (Fig. 17). In many varieties as Duchess there is a tendency for only one strong new branch growth to

FIG. 14.—WEAK LEADERS SHOULD BE LEFT LONG

If the branch which it is desired to have as a leader is weaker than the others, leave it longer (A), than in cases where the branches are well balanced. Wealthy.

arise, that from the terminal bud. Some others, of course, branch fairly well without tipping.

In case the trees do not make as much as 18 inches of growth it seems best not to do any tipping. Remove the crossing branches and let the others grow from the terminal buds. While this treatment gives rather unbalanced two-year trees, nevertheless it is not desirable to cut back to increase the number of branches unless the growth is over 18 inches long (Figs. 14, 15). The top can be balanced after its second growing season. It will be

FIG. 15.—KEEP THE TWO-YEAR TREE WELL BALANCED

Trees which grew too little the first season to need systematic heading back become unbalanced. Cut the stronger branches heavily (A) and the weaker ones lightly (B, C, D). The top should be kept more nearly level than the previous season. (Fig. 12). McIntosh.

FIGS. 16, 17.—THE TREE HEAD CAN SOMETIMES BE CHANGED

Some trees tend to send out new branches in the second season (1, A). A lower headed tree can be developed by using these latter as main branches if the previous leader is cut back heavily (1, B) as at 2. Cutting at 2, A would place the head still lower if desired, but a season's growth would be lost. Transparent.

larger and usually in better shape than if cut back too heavily as a yearling (Fig. 20).

When heading back the laterals, the cuts should be made to outside buds to help spread the top (Fig. 21) except for the case of horizontally growing branches, especially of some varieties (Fig. 20, E). The leader is headed so as to keep it in the center of the top, that is, cut to an inside instead of an outside bud.

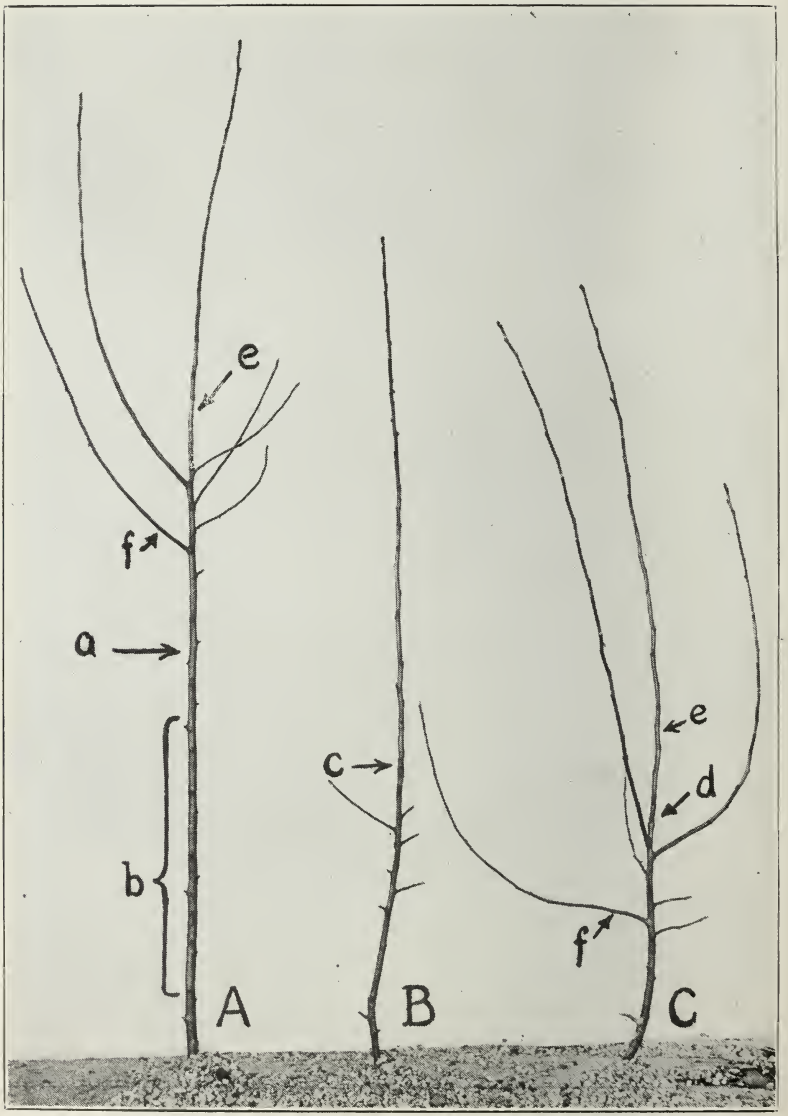


FIG. 18.—LEGGINESS AND BRANCH NUMBER CAN BE REGULATED BY PRUNING

By heading branch "A" back to "a", the branches and spurs would be in the region of "b". This method prevents excess height of tree. Weaker growing branches than "A" as "B" often produce but one good sized growth (c). Such limbs (C) can be made to branch well (e, f) if tipping (d) is done.

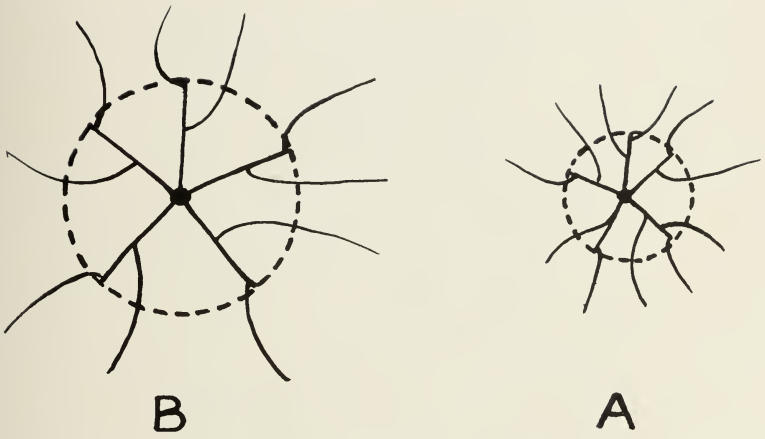


FIG. 19.—CUT THE BRANCHES BACK TO 18-20 INCHES IN LENGTH

Diagram showing need of good branch length (B) to give enough circumference of top to allow for an increase in branch number without crowding (A).

It will be noted (Figs. 12, 13, 18A) that the highest branch grows most nearly in the same direction as the one from which it arises. The lower branches take a more spreading position and form wider angles with the parent branch. Because of these facts the theoretical advice is frequently given that heading back should be done one bud above where it is desired to have the permanent branch. The tip branch is to be cut off a year later and a more spreading top secured. This is mentioned here in order to warn against general acceptance of this recommendation: it does not usually work in practice. The two main objections are:

1. Many varieties under ordinary conditions of vegetation do not force out more than two strongly growing branches near the cut. Both are needed in developing the top.
2. Removal of the strongest tip branch of every set where tipping was done is usually a too heavy pruning. (Light pruning usually gives larger and earlier bearing trees.)

Train the Two-Year Tree Carefully

Mistakes made at this stage in the life of the orchard tree can be overcome only at considerable expense and delay in the development of the fruitful tree. As with the yearling, tipping at the time of the regular dormant pruning is done to increase the

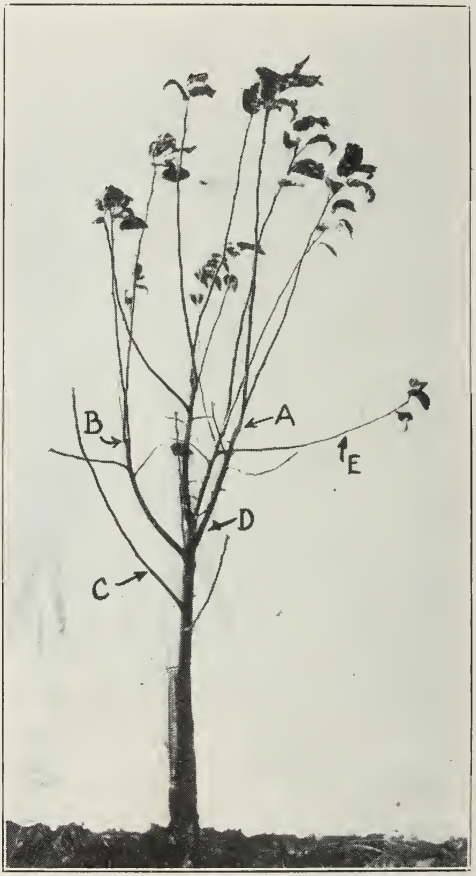


FIG. 20.—DO NOT CUT THE MAIN BRANCHES TOO SHORT

Several bad results follow cutting the branches too short: (1) There is not enough room for all the branches, (Fig. 19); (2) the new growths form bad notches (A, B); (3), the two-year branches seem to grow more upright, making bad crotches with the trunk, (D); low branches as "C" rarely become main limbs. In case a horizontal branch is left on it is headed back to an inside (top) bud (E). Duchess.

number of branches.[4] Also the branches are headed back unequally to prevent crotches (where the laterals branch). Additional objects are (1) the removal of crossing and crowding branches and (2) the choosing of additional scaffold branches.

Extra branches should be gotten out of the way before the other pruning is done (Fig. 22).

[4] Summer tipping is sometimes done but it does not usually result in appreciable beneficial results (Fig. 11).

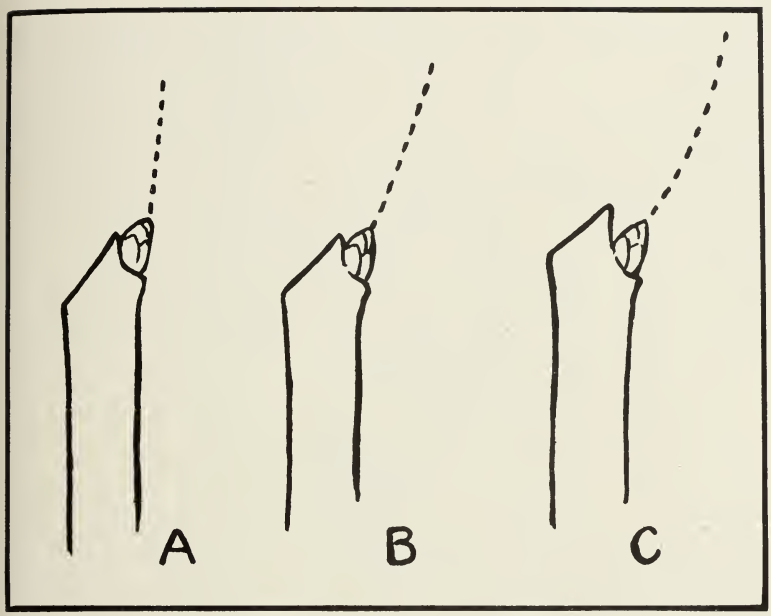


FIG. 21.—HEAD BACK TO OUTSIDE BUDS

Diagram of how the position of a cut affects the direction of the new growth from a bud. Close cutting (A) permits the new growth to take place almost in a straight line. Making the cut further from the bud (B) directs the growth more outward and cutting at a longer distance (C) causes the new growth to tend more toward the horizontal. Do not leave stubs which will not heal over readily.

One principal object of pruning the two-year tree is to increase the number of scaffold branches (Fig. 11). How many are wanted? Our present belief is that the best trees result from having eight to nine main branches. The main reasons why this number is best are:

1. A lower, more spreading tree is secured.
2. Many branched trees have a better fruiting system. That is, they usually bear earlier and produce larger crops of fruit during their first productive seasons.

Trees With Few Main Branches Become Tall and Narrow

The trouble with a central leader tree is that it grows too tall (Fig. 23). The so-called open center tree with its few main branches is largely subject to the same fault. The few main growing tips elongate so rapidly that they overgrow the laterals. That is, the proper balance between leaders and laterals is lost. Trees with many main branches do not grow tall so rapidly and

a better balance between branches keeps the laterals growing stronger so that a lower, more spreading tree is secured (Figs. 22, 24, 25).

The reason that few-branched trees become tall and narrow is largely because the laterals do not produce side branches but only send out a branch at the terminal or end buds. (Fig. 23). It appears from Figures 18A and 18B that the stronger growing branches produce the most new lateral branches. If the leader in a tree greatly outgrows the lateral branches the latter do not produce many side branches, but only one or two, even after having been tipped. The result is a tall narrow tree (Fig. 23). If the leader is kept in balance with the other main branches the latter send out more laterals and a spreading tree is produced (Fig. 24). This viewpoint suggests that the difference between an upright and a spreading type of tree of the same variety may not be due to hereditary characteristics but to

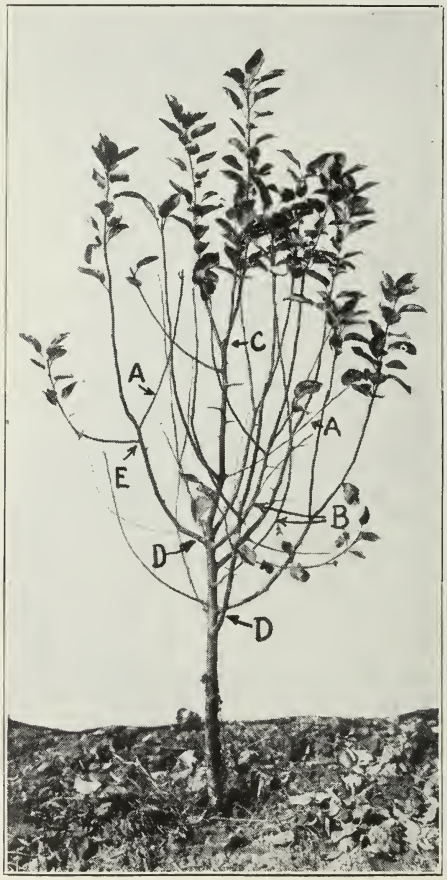


FIG. 22. — REMOVE CROSSING AND CROWDING BRANCHES FIRST

When pruning the two-year-old orchard tree take out useless branches, (A, A, B, B) before attempting to head back and balance up the permanent branches. This is a fine type of two-year-old Transparent. (Compare with Fig. 23.) The leader was headed back well (C) and kept in balance with the other branches. Note the tendency for lateral branches to form (E). See also the wide angle formed by the scaffold branches with the trunk (D, D) in this type of well-balanced many-branched tree.

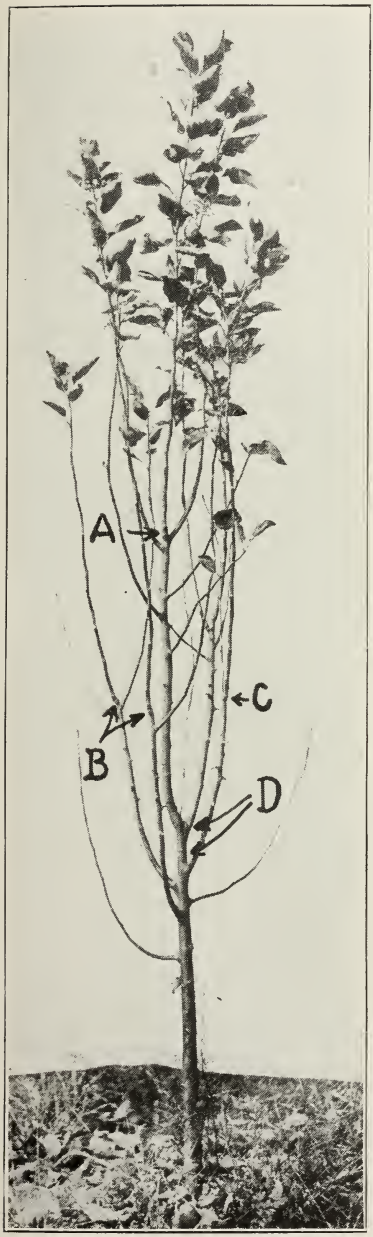


FIG. 23.—TREES WITH FEW MAIN BRANCHES AND A DOMINANT LEADER GROW TALL AND SLENDER

Compare with Fig. 11 and Fig. 22. The leader was left too much longer (A) than the laterals (B). The latter do not branch as well (C) as in balanced trees. Also the scaffold branches grow too upright (D). Note the excessive length of the new growth. If the tree had more branches as in Fig. 22 the growth would be more moderate. Transparent.

the influence upon form of branch number and balance between branches. Tall, narrow trees apparently can be largely prevented by proper pruning during the second to fourth year in the orchard. The principal means by which the trees are made more spreading is to develop a large number of scaffold branches which produce good lateral branches (Figs. 22, 24).

Pruning in the Third Year Is Also Important

As a rule, systematic shaping of the tree is also needed when it is three years old. Crossing, crowding and useless branches should be removed as in the two-year tree. Tipping does not always need to be done. After the third year systematic cutting back to increase the number of branches is not usually needed except for some (usually upright growing) varieties which do not branch freely. In case the terminal growth is over two feet in length it is advisable to head-in the tips to prevent excess height of the trees. (Fig. 18A).

The main purpose in pruning the three-year tree

is to overcome any tendency for it to become unbalanced (Fig. 26). To prevent any misunderstanding it should be stated that practically no consideration is given to the form (shape of outline) of the tree. That is left largely to be automatically adjusted by keeping the branches in balance. For purposes of this discussion the term balance refers to the "weight" (diameter and length) of the various branches. A condition of balance

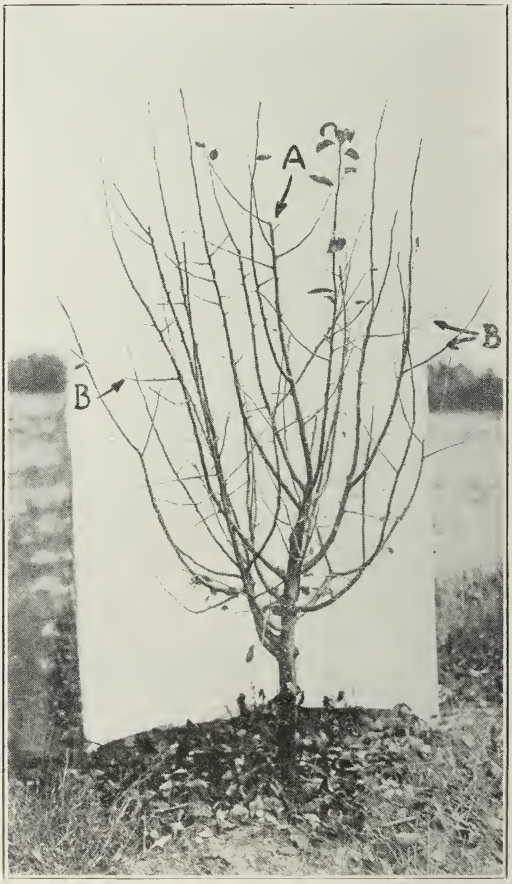


FIG. 24.—MANY-BRANCHED TREES WITHOUT A DOMINANT LEADER ARE MORE SPREADING

Practically all of the main branches are of the same size. Compare with Fig. 23. The leader should be definitely suppressed at "A" or even lower. Note the desirable development of lateral branches (B, B). This is a tree "full of brush," but yet rather typical of Transparent. The top is relatively flat and open to the light. It can be expected to bear at a much younger age than tall narrow trees, Fig. 29 and Fig. 33.

exists when the branches of a set, as the scaffold limbs, have a uniform size and amount of top (Figs. 1, 27). An unbalanced condition is when one or some of the branches have grown overlarge in comparison to the others (Figs. 28).

The object in keeping the wood growing uniformly is to develop a uniformly fruitful bearing surface. To do this it is necessary to keep the lower branches strongly vegetative and not let them be outgrown by one or two of the center limbs (Fig. 29). It is during the second to fourth year of the average tree that this matter can be regulated. Watch the three-year tree to

FIG. 25.—A FINE TYPE OF YOUNG GRIMES

Note the relatively large size of the lower branches (A, B). The leader was suppressed early (C). A somewhat greater length is often desirable. This tree will develop into the type in Fig. 2 and not like Fig. 3.

FIG. 26.—KEEP THE THREE TO FOUR-YEAR-OLD TREE BALANCED UP

In central leader trees the leader outgrows the lower branches. With modified leader trees one branch (A) sometimes assumes the lead. Check these by cutting back heavily (B). McIntosh.

keep the branches growing evenly. Severely head-in those which tend to grow too strongly (Fig. 26).

Very little can be definitely stated about how to change open center trees into modified leader trees because the former differ so greatly among themselves. They are too unlike to be covered by specific rules. In general, do not attempt to change them after the third year. Let the tree go and brace it later. Previous to the fourth year the change can usually be made successfully if one of the scaffold branches can be given the lead (Figs. 30,

FIG. 27.—LOW SPREADING TREES BEAR EARLIER

Openness of top accompanies the spreading form. This gives early bearing. McIntosh. Same tree as Fig 1.

31). In any case do not let the scaffold branches assume the lead to such an extent that they over-grow and smother out, as it were, the lower laterals (Fig. 29).

As to the treatment of trees which are deformed by prevailing winds, contrary to what is frequently done, the tree should really be cut heaviest on the side *away from the wind* (Fig. 32). This recommendation is based on the principle of growth that the strongest branches should be cut most in order to keep the top balanced (Fig. 9). Heavy cutting on the windward side would further unbalance the tree.

Do Less Pruning After the Fourth Year

It is pretty generally believed that there should be "as little pruning as possible" during the four to six year period. Heavy pruning at this time maintains the tree in a vegetative condition and as a consequence tends to retard fruiting. The need for doing little pruning does not, however, prevent the removal of extra and crossing branches. The trees should still be watched to keep the branches balanced (Fig. 33).

FIG. 28.—WELL FORMED HEADS MAY BECOME UNBALANCED

The branches of this tree are spaced better than in Fig. 1. Yet two branches (A, B) have been permitted to outgrow the others and unbalance the top. Note the upright position assumed by the branches A and B. McIntosh.

Very often the trees do not begin to bear even after they are five or six years old and are large enough to fruit well. It appears that in many cases where the trees are growing rapidly this delay is directly related to the density of the top. Light conditions are too poor for blossom buds to form. This has been found to be the case quite certainly with McIntosh, in some sections (Fig. 27). How can pruning help this condition when the usual result of cutting young trees is an increase in number of branches and especially density of foliage? Certainly a non-fruiting tree can not usually be kept more open than its habit permits for it fills up with suckers after being "opened up." This over-density of top can be avoided by thinning out the top *in the*

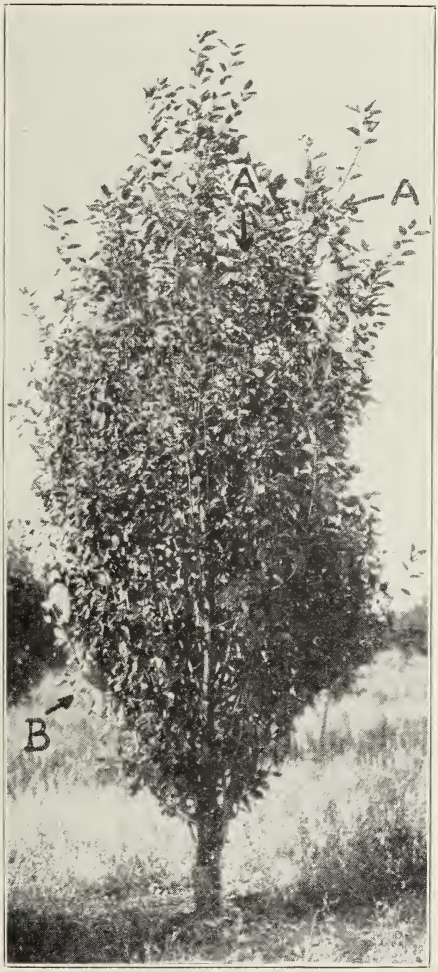


FIG. 29.—A TALL NARROW TRANSPARENT IS SLOW TO BEAR.

Note the strong leader. Some terminal fruits have been borne (A). The top is, however, too dense for spur blossom buds to form. See how weak the lower branches are. Compare with the younger tree of Fig. 24.

early summer after the new terminal growths are several inches long. No tipping is done. Excess branches are cut out. Very little suckering will result so the top will remain relatively open during the month of June, while blossom buds are usually being differentiated. This pruning is not a part of a rather fixed pruning program but is, instead, a special practice applicable only to the condition described (Fig. 29). It is mentioned because of

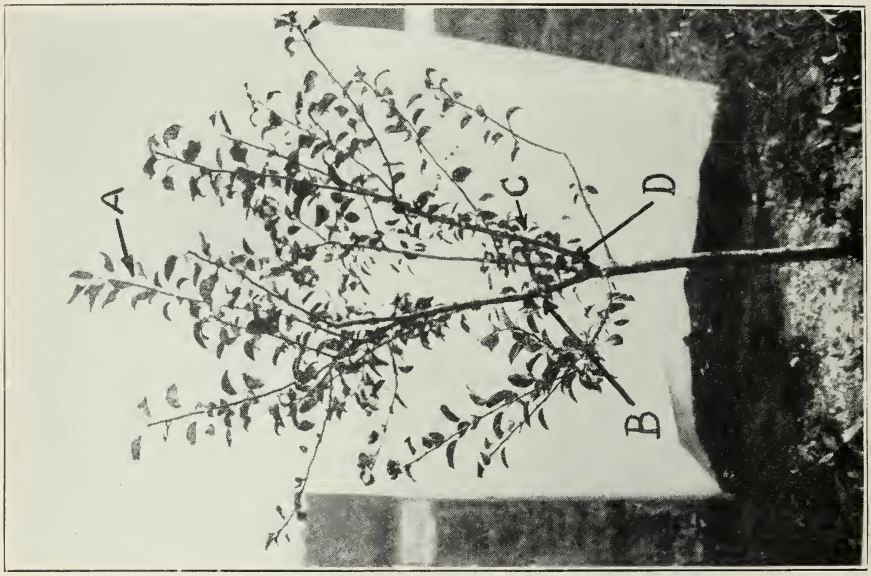


FIG. 31.—HOW TO CHANGE THE OPEN CENTER TREE

FIG. 30.—OPEN CENTER TREE CAN BE CHANGED

FIG. 32.—WIND-BENT TREES CAN BE BALANCED UP

Cut heavily on the side away from the wind (A). Leave the branches longer on the windward side (B). In this case the leadership has changed from branch "A" to "B". McIntosh.

its frequent need. The common practice in such cases is to wait "until the tree spreads under a load of fruit." This is all right except that waiting is unprofitable and the load of fruit is too long in coming. Frequently trees as in Figure 29 will produce terminal blossom buds and bear some apples but a real crop is not secured until spur blossom buds are formed. Good light conditions throughout the top are needed for these to form abundantly.

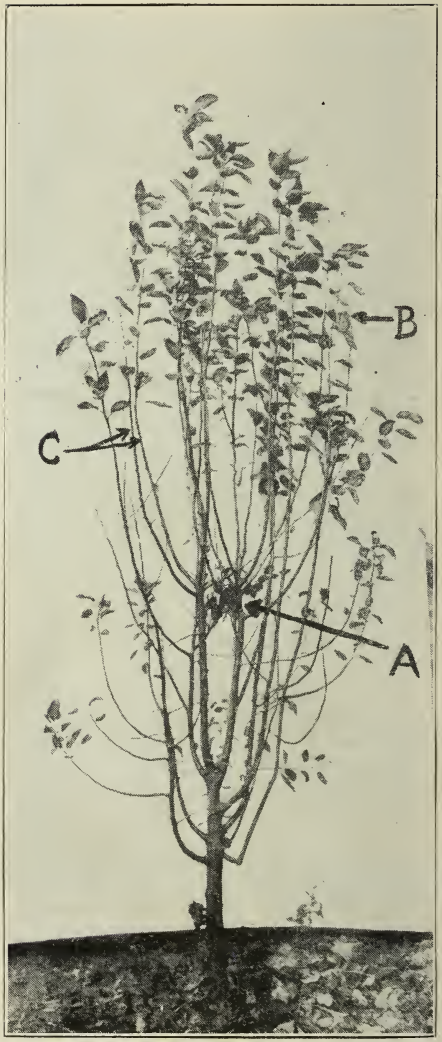


FIG. 33.—LITTLE CAN BE DONE TO BALANCE OLDER TREES

Heavy cutting as near "A" is hardly advisable although this would be necessary to give the lower branches a chance. A tall tree with few lateral branches (C). Note the very long terminal growths (B). Compare with Fig. 24. Transparent.

After the trees have reached an age of five to six years the pruning for form is usually completed and subsequent pruning is for the purpose of maintaining the trees in maximum fruiting. This latter pruning is also based upon the principle of keeping the top in balance but is of a somewhat different type.

Bulletin 355

June, 1923

Nicotine Dust Kills Cucumber Beetles

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

The striped cucumber beetle is a constant crop hazard and damages cucurbit crops to the extent of $3,000,000 to $5,000,000 annually although the loss to a single grower is seldom seriously felt because of the usual small plantings. Page 3.

Nicotine dusts have been found most effective in killing the beetle outright and making unnecessary the protection of vines from beetle attack throughout a large part of the season. Page 4.

Nicotine dusts containing copper sulfate or gypsum mixed with the lime carriers do not lose strength rapidly and have been found effective against the beetle under all conditions. Page 4.

Dusts containing 10 per cent nicotine sulfate are preferred, but as it is impossible to purchase this strength, the 5 per cent dusts will do much to alleviate damage. Page 5.

Nicotine dust containing 8 per cent sulfate and 25 per cent copper sulfate is believed to be the most stable and therefore the most reliable dust to use against this insect. Such a dust does not appear to be on the market at present. Page 5.

Nicotine dusts with active carriers, such as hydrated lime and unslaked lime, lose strength rapidly and control the beetle only under the most favorable conditions. Page 6.

Cucurbits should be dusted early as soon as they are up and beetles commence to attack them. Early dusting kills beetles, saves time, expense, and the crop. Page 8.

Dusting should be done cooperatively by all growers of the neighborhood because beetles can fly as far as two miles. Three applications of dust during a ten day period will usually be enough to secure control if your neighbors do likewise. Page 8.

Dusting should be done properly, using a hand duster and applying enough dust to thoroughly cover the plants, beetles, and cracks in the ground. Dust should be applied rapidly to prevent any beetles flying away; and to accomplish this, a canvas cone is helpful. Page 8.

Fourteen pounds of dust per acre costing $2.25 (for 5 per cent dust) will be required when plants are small. Dust stronger in nicotine will cost from one-third to one-half more. Page 10.

Wind reduces effectiveness of nicotine dusts. Dusts are most effective when no wind is blowing and the temperature is 65° F. or higher, but dusting should not be put off long on account of weather conditions. Page 10.

Nicotine Dust Kills Cucumber Beetles

JOHN E. DUDLEY, JR*., H. F. WILSON AND W. D. MECUM

THE STRIPED cucumber beetle is a constant crop hazard. It causes damage estimated at from $3,000,000 to $5,000,000 annually to the cucurbit crop (cucumber, melon, squash) of the United States. This insect not only injures the plants by its feeding, but also transmits the wilt and mosaic diseases. Although the loss to individual growers is seldom seriously felt because the plantings are small, yet the total annual loss is great.

Most Insecticides of Little Value

Many insecticides used in the past were found to be powerless against the cucumber beetle. Nicotine dust, a new form of insecticide, has proved decidedly successful in the control of the beetle during two years of trial.

Fig. 1.—THE STRIPED CUCUMBER BEETLE

This beetle is a dangerous enemy of cucurbits and great losses occur annually from its ravages.

Over 60 different insecticides were thoroughly tested at this station during the past seven years. A few of them were of some value in repelling the beetle yet none were worth recommending as a satisfactory control. Even the stomach poisons ordinarily used against chewing insects were not effective in killing this pest although they showed some repellent effect, because the beetle is more or less repelled by any foreign substance on the leaves. Therefore, so long as the foliage was kept quite well covered with dusts or sprays, the plants remained fairly free of beetles, but to keep them constantly covered (Fig. 2) proved a costly undertaking, for as soon as

* John E. Dudley, Jr., Entomologist is in charge of a federal field station at Madison, Wisconsin where this work was carried on cooperatively with H. F. Wilson of the Wisconsin Agricultural Experiment Station. W. D. Mecum, of the federal force, is responsible for the experimental work with carriers for nicotine dusts.

rain or wind removed the material or new growth appeared the beetle flew right back from nearby gardens. Beetles are nearly always on the move and trying to keep them away from a patch of cucurbits is almost a hopeless task.

Fig. 2.—CUCUMBER VINES HEAVILY DUSTED TO REPEL BEETLE
The vines covered with dust or spray are protected but the new growth in the foreground is open to attack.

Nicotine Dust Best

Tests over a period of two years have clearly shown that nicotine dust, is a decided success in the control of the striped

cucumber beetle when properly applied. During the growing seasons of 1921 and 1922 various forms of nicotine dusts were given severe tests under field conditions to find what combinations would stand up best in general use. Nicotine sulphate was combined with gypsum, sulfur, and several forms of lime, and all the combinations were more or less effective in killing the beetle. In addition to these a new material was developed at this station in 1921 which promises to be more effective than the simple mixture of nicotine and lime against the beetle, as well as against several other insects. This material was made of nicotine sulfate, 1 part, monohydrated copper sulfate, 5 parts, and hydrated lime, 14 parts.

In testing the various materials each one was used frequently against hundreds of beetles, confined in large cages, and on plants in the open. The different results obtained for the same strength of material in different tests are due to variations in the weather, amount of dust applied, size of plants, and freshness of the material.

Nicotine-Lime 5 per cent—With nicotine-lime containing 5 per cent of nicotine sulfate the percentage of beetles killed varied from about 10 in one test to 96 in another. The average percentage was 60 to 85. This material appeared to be rather unstable, and killed many beetles in some tests and only a few in others. As its success in killing depended upon its absolute freshness and the most favorable weather for its application, this dust is not as satisfactory for general use as some others.

Nicotine-Lime 10 per cent—Nicotine-lime containing 10 per cent nicotine sulfate carried twice the amount of nicotine and cost a half more than the previous dust but the percentage of killing obtained with it was much more consistent, running from 83 to 98 with an average of 90. While this dust loses strength just as rapidly as the 5 per cent dust and is affected the same by the weather, yet it contains enough nicotine to kill a large percentage of the beetles even when it is not strictly fresh and when used in unfavorable weather. Therefore, except for its greater cost, it is preferable for general use to the 5 per cent dust.

Nicotine-Copper-Lime 5 per cent—This new combination, nicotine-copper sulfate-lime containing 5 per cent nicotine

sulfate, appeared much more stable and killed more consistently than the 5 per cent nicotine-lime. The percentage of beetles killed varied under different conditions from 63 in one test to 100 in several tests, and averaged 85 to 90. Pulverized copper sulfate in this dust rendered the nicotine less volatile and therefore greatly reduced the rapidity of its escape from the dust. Whether its greater effectiveness against the cucumber beetle was due to a reduction in the loss of nicotine, or to a slower rate at which nicotine was given off after coming in contact with the insect's body, is not known at this time, but it is probably a combination of the two.

Nicotine-Copper-Lime 10 per cent—Nicotine-copper sulfate-lime containing 10 per cent nicotine sulfate was used in only one series of tests and proved completely efficient as was expected. Ten per cent of nicotine was found to be more than necessary when copper sulfate was present.

Nicotine More Effective With Certain Carriers

In a series of tests to determine the best carriers (fillers) for the nicotine, six different substances were used; hydrated lime (calcium hydrate), air slaked lime (calcium carbonate), unslaked lime (calcium oxide), gypsum (calcium sulfate), sulfur, and copper sulfate with hydrated lime. Mixtures containing hydrated lime or unslaked lime, both of which reacted with the nicotine sulfate liberating nicotine, did not kill as high a percentage of beetles as did mixtures containing gypsum or copper sulfate. Mixtures containing air slaked lime or sulfur were about half way between. When a small amount of unslaked lime was added to the hydrated lime, the loss of nicotine was greater and the killing effect less than when the unslaked lime was left out.

When any form of lime was used as a carrier the resulting dust was light and dry. With gypsum however, there was a tendency for the dust to absorb moisture which made it heavy, therefore a combination of gypsum and hydrated lime appears to be superior to gypsum alone.

Against certain insects which are easily killed by nicotine fumes, such as the aphides or plant lice, a dust in which the nicotine is liberated quickly appears to be most effective. Against the cucumber beetle and certain other insects, however, the best results have been secured by using a dust in which the nicotine is rather stable.

Nicotine Dust Loses Strength Rapidly

All dusts containing nicotine should be kept in tight, metal cans all the time and the can should always be covered except when dust is being removed. As these things are not always done a test was made to determine the effect upon the nicotine when dusts were exposed in shallow dishes for different periods of time.

Dusts containing hydrated and unslaked lime which, when fresh, killed 100 per cent of the beetles treated, after being

Fig. 3. -BELLOWS TYPE HAND DUSTER

This duster throws an intermittent stream of dust and is excellent for dusting plants grown in hills.

exposed for three or more days killed only 40 to 70 per cent of them. This loss of nicotine was greatly increased when dusts were exposed in a damp place.

When dusts containing sulfur, with 2 per cent nicotine sulfate, were exposed to the air for 24 hours, the percentage of beetles killed dropped from 60 to 30.

When dusts containing copper sulfate were exposed to the air the loss of nicotine was very much less. After six days'

exposure the killing effect dropped from 100 per cent to only 90 per cent. Even this loss of nicotine is appreciable and could be prevented.

Dust Cucurbits Early

The time to kill the cucumber beetle easily, quickly and in large numbers is when it first attacks the small plants. Beetles congregate in large numbers on the squash, melon, and cucumber plants and feed ravenously on the first thick leaves or cotyledons. The beetles are in a small area, are usually quite sluggish, and a few good puffs of dust will kill 95 per cent or more of them. These first beetles produce the thousands to follow and if 95 per cent of them can be killed, there is little danger from the progeny of the other 5 per cent. When vines are beginning to run there is much more area to be dusted, the beetles are more active on account of the warmer weather and the number killed will be scarcely more than 60 per cent to 70 per cent.

There is a period of from 7 to 10 days in which the beetles can be profitably and easily controlled. After this period it takes constant effort and considerable expense to protect the vines from beetles.

Dust Cooperatively

It would be better if growers in the same vicinity would dust at the same time to secure uniformly good results, for beetles soon find their way from the half-eaten, untreated patches to the clean ones. Dusting is not done just to protect the vines, as is spraying for the codling moth, but to kill the beetles in order that they may not cause later trouble. If every cucurbit grower who is less than one mile from his neighboring growers will faithfully dust for the beetles at the right time, there should be little further trouble that year from beetles or from the wilt. Beetles may fly as far as two miles but the majority seldom go over three-fourths of a mile.

Dust Properly

In order to be sure of killing the beetles under all conditions, a nicotine dust containing at least 5 per cent of nicotine sulfate (2 per cent of pure nicotine) and preferably 10 per cent (4 per cent of pure nicotine) should be used. According

to R. E. Campbell[1] many growers prefer a 10 per cent nicotine dust as they are much surer of overcoming the beetles before any escape. Dust should be purchased in sealed cans direct from a dealer and must be fresh, that is, not held over from a previous year. A hand duster (Figs. 3 and 4) is necessary for applying the material properly and may be purchased from any of several firms manufacturing dusts and spray machinery. If a duster is not available the material may be shaken from a cheesecloth sack directly over the beetles, but this

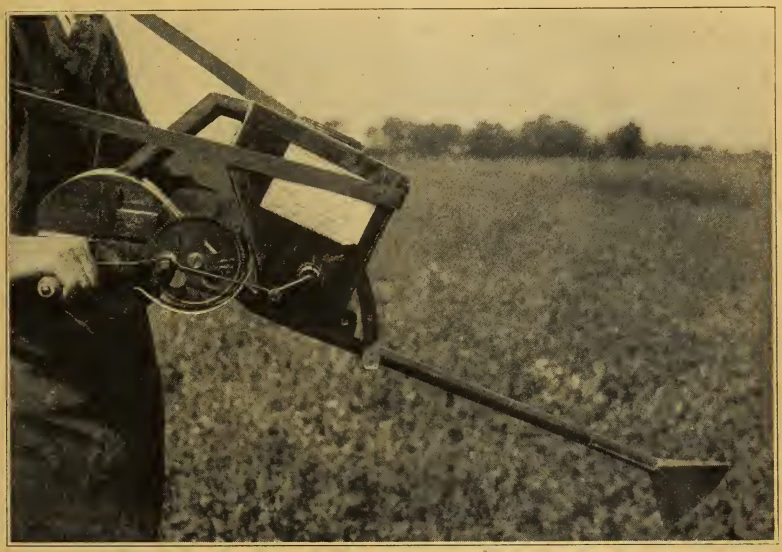


Fig. 4. -FAN TYPE HAND DUSTER

This type of duster throws a continuous stream of dust and is much superior to a sack or can. Its greater effectiveness soon repays the cost.

method is decidedly inferior to a duster.

Before plants have started to run, dusting may be made more effective by the use of a canvas cone (see cover page) which is quickly dropped over the plants to prevent the escape of any beetles and also to keep the dust from blowing away. This cone is helpful in dusting other plants such as cabbage, cauliflower, and small tomatoes. The plants should be approached carefully so that no beetles will fly away; and heavy puffs of dust should be blown directly on them.

1 **Campbell, R. E.**—Nicotine Dust for Control of Truck-Crop Insects. U. S. Dept. Agr. Bul. 1282, p. 21, Sept. 1922.

W. H. White[2] states, "As the insects are very active and take flight at the slightest disturbance, an apparatus which will throw a good volume of dust with force . . . . . is necessary." Apply enough dust to each hill to cover all the beetles and to fill cracks in the ground where they may be hiding, for it is a great deal quicker and cheaper to dust thoroughly when plants are small than to wait until there is a mass of foliage. Nicotine dusts are most effective against the cucumber beetle when the air is still and the temperature is 65° F. or higher. Nevertheless, it is important to attack the beetles as soon as they gather on small plants in order to kill them off and save the seedlings.

Usually three applications of dust at two day intervals are sufficient to rid the plants of beetles provided nearby patches are similarly treated. The usual amount of dust to use when plants are small is from 12 to 16 pounds per acre. At the present price[3] of 5 per cent nicotine-lime dust ($16.00 per hundred), 14 pounds would cost about $2.25 per acre per application. Dust containing more than 5 per cent of nicotine sulfate does not seem to be on the market at present. While dusts containing copper sulfate, gypsum, or some other inert carrier are more successful against the cucumber beetle than the active dusts; they also do not appear to be manufactured at present. One dust containing copper sulfate, lead arsenate, lime, and nicotine sulfate 5 per cent is quoted by one firm at $20.00 a hundred.

The ordinary nicotine-lime dust containing 5 per cent nicotine sulfate is very effective against the melon aphis (or louse) which occurs in such vast numbers during July and August on melons and cucumbers.

2 **White, W. H.**—Nicotine Dust for Control of the Striped Cucumber Beetle. U. S. Dept. Agr., Cir. 224, p. 2, June, 1922.

3 April, 1923.

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Corn Breeding

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

Why?

1. Why do red ears of corn appear in yellow or white varieties when no red seed is ever planted? Pages 18-20.

2. Why are white kernels constantly found in yellow varieties even when they are discarded every year before planting? Page 22.

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Corn Breeding

E. W. Lindstrom

CORN BREEDING is a source of both pride and profit to many enterprising farmers.

The local breeder of corn is always needed despite the well developed federal and state experiment stations and reputable seed companies that are constantly breeding corn. This crop demands constant breeding to adapt it to different parts of the state and especially to keep the variety pure. Since all this cannot be done by the state experiment station, some local breeder must develop reliable seed corn for his neighborhood.

Selecting the best ears in the field is a simple method and is economically done although there are many complicated systems.[1]

Such questions as those asked on the opposite page are very common to any one growing seed corn.

If the answers to the questions do nothing else, they should at least indicate what not to do under certain circumstances, which would often mean a saving of time and money.

Some corn breeders whose breeding stock produced a high proportion of white seedlings have treated their seed, others have used excess of fertilizers, and still others have spent hours hoeing out white seedlings or have worried about diseases and insects in their soil. None of these treatments, as a matter of fact, affect in any way the appearance of the ordinary white seedlings and only when the cause is found can the situation be handled wisely.

A study of the heredity of the corn plant often answers many questions about corn. Breeding is based on a knowledge of the inheritance of characters and qualities. This in itself is a fascinating subject and has considerable importance from the commercial standpoint. The corn breeder, the county agent, and the agricultural teacher must know some-

[1]The ear-to-row method, the ear-remnant method, or the method of using hybrid seed are probably impractical to the average corn breeder at this time. Information and help in any of these methods can be had from the Agricultural Experiment Station at Madison.

thing of the way in which characters are transmitted or inherited in order to deal with plant breeding intelligently.

The corn plant is well adapted to a study in heredity. First, there are large numbers of different types of corn such as dent, flint, sweet, pop, flour, red, white, yellow, purple, podded, and a score of other types; and second, corn is easily cross-bred. The crossing of corn, which is its natural method of pollination, is so important in breeding work that it should be well understood.

How Corn is Pollinated

Corn is naturally cross-pollinated. It differs in this respect from wheat, oats, barley, peas, beans, and soybeans, all of which are naturally self-pollinated. The wind blows the corn pollen about, sometimes as far as half a mile, scattering the pollen so that it falls on plants other than the one producing it.

In corn the male element, the pollen, is produced in the tassels while the female element, the eggs or ovules are borne on the young cob. Each normal healthy corn plant produces over 2,000,000 pollen grains and about 500-1000 ovules.

To produce a normal ear of corn, at least one pollen grain must fall on each silk, grow down this long thread-like affair and finally fertilize the ovule or egg at its base. This soon produces the young embryo plant seen in the corn grain, as well as the starchy food material surrounding the young plant, each fertilized ovule producing a single kernel. If any of the silks fail to receive pollen, or if for any other reason the ovules fail to develop, there is a corresponding deficiency of kernels. This condition is commonly seen at the extreme tip of the ear.

Because of the distance between the tassel and the silks on a corn plant (from 2 to 4 feet) and because the pollen is very light in weight, there is much chance that the plant's own pollen will be blown aside and that the silks will be pollinated by pollen from another plant. This is what is meant by cross-pollination. Sometimes the pollen matures at slightly different times from the silks, a fact which also aids cross-pollination.

Cross-pollination makes corn breeding difficult. The mother plant can be controlled by saving its seed but the male contribution is always uncertain. Experience shows that the male plant has as much effect on the progeny as the female, and accordingly it cannot be neglected.

Pollination can be artificially controlled by bagging the plants. This is, however, impracticable as an ordinary corn breeding method.

Structure of Corn Grain

The make-up of the corn grain is another matter that should be understood in discussing the heredity of corn. As seen under the microscope, the kernel of corn has the following constitution, shown in the diagram.

Beginning at the outside, there are several layers of thin cells called the seed-coat or pericarp. Inside this is a single

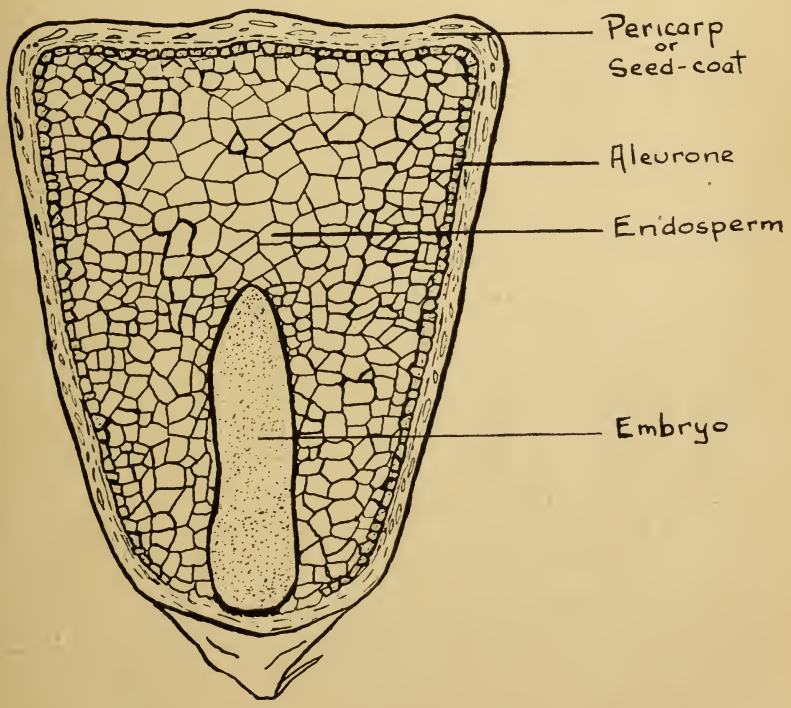

FIG. 1—DIAGRAM OF A CORN GRAIN

A cross-section sketch showing the relative location of the different parts of the kernel.

distinct series of cells called the aleurone layer. See Fig. 1. Next come the larger and looser starch cells of the endosperm proper. These cells surround the young corn plant (embryo) and contain the food materials for the germinating seedling until its own roots and leaves can function.

Each of these three kinds of cells may carry distinctive colors. In addition, the endosperm cells may contain different kinds of starch (or dextrin), making the kernel a dent, flint, pop, flour, or sweet corn.

Colors of the Grain

Seed coat color. As a rule two general colors, red and white, occur in the seed-coat.[2] Such varieties as Cardinal King Dent, King Phillip Flint, and Northwestern Dent, have red seed coats. The white or colorless seed coat is found in Golden Glow Dent, Murdock Dent, Clark's Dent, Silver King Dent, Crosby Sweet, Golden Bantam Sweet, Black Mexican Sweet, Country Gentleman Sweet, Yellow Flint, White Flint, Rice Pop, and many others.

All ears on any individual plant are entirely of the same color, either red or white. Very rarely bud sports occur, in which case red and white seed coat colors may be found on the same plant.

The seed coat of the corn grain belongs to the mother plant, while the endosperm (starchy food materials), including the aleurone layer, belongs to the young embryo plant contained therein. The seed coat is produced by the mother plant as can easily be seen by placing a bag over an ear before the silks come out. If this is done neither the endosperm nor embryo develop within the thin seed coat which is already present. If fertilized by pollen, however, the embryo plant, the endosperm and the aleurone layer develop within this seed coat. It is very important to realize that the seed coat belongs to one generation (parent), and the endosperm and embryo plant to the next generation (progeny).

Aleurone color. Commercially, aleurone color in corn does not play a very important part. But sometimes it does cause a contamination of good seed corn as every farmer knows who has seen ears speckled with blue grains. The only im-

[2]Occasionally others are seen, such as calico (striped red and white), brown, or lighter shades of red, but these are not of great commercial importance. The red tint of smut-nosed flint is carried in the seed coat and is developed by the gradual entrance of light at the upper end of the ear.

portant varieties which have aleurone color are the Black Mexican Sweet Corn, Squaw Corn and the Blue Pop Corn. The native Indian corns also contain much aleurone color.

There are three general colors carried in the aleurone layer of cells which lies immediately below the seed coat and forms the outer layer of the endosperm. These are purple (or bluish-black), red, and colorless. There are no commercial varieties with pure red aleurone color. The common white or yellow dent and flint corns have the colorless aleurone, as do the red seed-coated varieties. It is possible, however, to produce by cross-breeding an ear with a red seed coat overlying a purple aleurone color, making a dark red combination. In other words, the seed coat and aleurone colors are independent of each other; one or both may be present in the same grain.

Endosperm color. The endosperm proper lying within the aleurone layer carries its own series of colors. They range from a dark orange-yellow to white, with all gradations of yellow color intervening. The Golden Bantam sweet corn contains one of the darker shades of yellow, while the Yellow Flint, Golden Glow, Murdock or Reid's Yellow Dent varieties are just a trifle lighter in shade. The endosperm color of Silver King, Boone County White, Silver Mine, White Flint, or Cardinal King is white or colorless.

The yellow series of endosperm colors is independent of both seed-coat and aleurone color. That is, we may have either yellow or white endosperm overlaid by either red or white seed coat or by either purple, red or colorless aleurone. A red variety like Cardinal King may have both yellow and white kernels. As a matter of fact, Cardinal King has a large majority of white kernels.

Cob Color

The cob like the seed coat is a part of the mother plant. There are two general colors of the cob, red and white.[3] Varieties such as Golden Glow, Reid's Yellow Dent, Leaming, Murdock, Clark, and Cardinal King have red cobs. White-cobbed varieties are Silver King, Silver Mine, Boone County White, Evergreen Sweet, Crosby Sweet, Golden Bantam Sweet, and Country Gentleman Sweet.

[3]Other colors such as brown, purple, or red-striped (of calico corn) are sometimes found, but they are not very important commercially.

TABLE 1.—COLORS OF CORN VARIETIES

VARIETY	SEED-COAT COLOR	COB-COLOR	ALEURONE COLOR	ENDOSPERM COLOR	AVERAGE NO. ROWS
Golden Glow Dent	Colorless	Red	Colorless	Yellow	16-18
Reid's Yellow Dent	Colorless	Red	Colorless	Yellow	16-18
Murdock Dent	Colorless	Red	Colorless	Yellow	16-18
Clark Dent	Colorless	Red	Colorless	Yellow	16-18
Silver King Dent	Colorless	White	Colorless	White	16-18
Cardinal King Dent	Red	Red	Colorless	White	16-18
Northwestern Dent	Red (capped)	White	Colorless	White	14
King Phillip Flint	Red	White	Colorless	Yellow	8
Yellow Flint	Colorless	White	Colorless	Yellow	8
Longfellow Flint	Colorless	White	Colorless	Yellow	8
White Flint	Colorless	White	Colorless	White	8
Smut Nose Flint	Colorless (red tip)	White	Colorless	Yellow	8
Golden Bantam Sweet	Colorless	White	Colorless	Yellow	8
Crosby Sweet	Colorless	White	Colorless	White	12
Hickox Sweet	Colorless	White	Colorless	White	12-14
Evergreen Sweet	Colorless	White	Colorless	White	16-18
Country Gentleman Sweet	Colorless	White	Colorless	White	Irregular
Black Mexican Sweet	Colorless	White	Purple	White	8
Blue Pop	Colorless	White	Purple	White	12

A summary of the different colors of a number of corn varieties is arranged in Table I.

Different Kinds of Endosperm

Besides color, the endosperm of the corn grain carries other qualities such as the dent, flint, pop, flour, or sweet characteristics. These qualities are caused by the distribution and the nature of the starch contained in the endosperm of the grain.

Dent Corn. This is the characteristic type of grain developed in commercial varieties grown in the corn belt. There are all degrees of denting of the kernel, running from the deep, rough dent of the Riley's Favorite and Clark Yellow Dent varieties to the shallow, dimpled dent of the Early Yellow Dent (Wis. No. 8) or Northwestern Dent varieties. The rough type seems better adapted to the southern areas of the United States, while the smooth or shallow dent is most often seen in the northern limits, where earliness of maturity is necessary.

The dent in the corn kernel is conditioned by the arrangement or location of two kinds of starch, the soft (dull) and the hard (shiny). The soft starch in dent corns is ordinarily located around the small embryo and extends from there until it covers the top of the seed. The hard, shiny starch is formed only at the sides of the grain. As the kernel dries on maturing, the soft starchy area shrinks much more than the hard and causes the denting of the kernel at the top. The hard starch at the sides prevents any denting or shrinking there.

Flint Corn. Flint varieties such as Longfellow, King Phillip, Smut-nose, and White Flint, have the two kinds of starch, hard and soft, but they are distributed differently than in the dent corns. The soft starch practically surrounds the embryo. It is covered entirely by the hard, shiny starch. When the flint kernel dries, it shrinks evenly at all points, making a uniformly hard, smooth grain.

Flour Corn. In the flour corns there is practically no hard starch, only the soft starch surrounding the embryo. This

shrinks uniformly on drying giving a smooth kernel, which is soft and somewhat dull in appearance.

Pop Corn. The endosperm of the kernel in pop varieties is practically all hard starch. This dries to form a small but unusually hard and smooth kernel.

Sweet Corn. Sweet or sugar corn when dry has a characteristic wrinkled appearance of the kernels. This is true of all the varieties such as Golden Bantam, Evergreen, Crosby, Hickox, Country Gentleman, or Black Mexican. It is said that sweet corn has lost the ability to mature starch normally.

There are several types of sweet corn based on kernel characters. One is typified by the Evergreen variety, in which the dried, wrinkled grains show a conspicuous dent at the top of the kernel. This is nothing but a dent corn which has lost the ability to form starch normally. Another type is found in varieties like the Golden Bantam or Crosby, which have no conspicuous dent in the kernels. The grain is uniformly wrinkled and not prominently dented. Such varieties are nothing but latent flint corns. These statements are easily verified by making crosses of the different sweet corn types with both flint and dent varieties.

Defective and abortive endosperm. Within recent years, the plant breeder has found that many of our best commercial varieties of corn, especially when inbred, show a certain percentage of defective or abortive grains. Usually these are not caused by poor conditions of growth but are hereditary. In general there are two sorts of abnormal grains. (Fig. 2). In one the food materials (endosperm) have completely aborted leaving only a thin, papery hull (seed-coat) instead of a full grain. Such grains will not germinate. In the other sort the grain is defective in the amount of endosperm produced, thereby reducing the percentage of germination or producing weak seedlings. In either case the appearance of the ear is impaired by these abnormal grains.

Seeds of both these types have been found in practically all commercial types of corn, whether dent, flint, or sweet. corn. Once in a variety it is very difficult to eliminate them, and they will persist in spite of all ordinary precautions.

General Characters of the Seed Ear

Taking the ear as a whole, there are numerous and different characteristics which are worthy of attention.

Number of rows. There is a wide range of variation in the number of rows of our commercial varieties of corn. They range from the eight-rowed condition, characteristic of most

FIG. 2—DEFECTIVE KERNELS

Two hand-pollinated ears showing a sprinkling of defective grains. Such abnormal grains are hereditary, and are found in most varieties of corn, especially when inbred closely.

of the flints, Black Mexican Sweet and Golden Bantam Sweet corn, to the 18-20-22-24, or 26-rowed condition of the larger dent and sweet varieties.

Within the varieties themselves there is considerable variation, especially in the dent varieties. For example in varieties like Golden Glow, Silver King, Cardinal King, Murdock's Yellow Dent, Early Evergreen or Stowell's Evergreen, we sometimes get the complete range from 8 to 26 rows in an ordinary field of any size. The average is usually about 16 to 18 rows, there being very few of the extreme conditions.

Among the flints (Yellow Flint, White Flint, King Phillip) and the sweet varieties like Golden Bantam or Black Mexican there is much less variability. The great majority are 8-rowed, only occasionally do we get 10- or 12-rowed ears.

There are also varieties like the Crosby sweet corn and some of the popcorns that have a general average of 12 rows. The variability here is not so great as in the dent corns nor so limited as in the flints. Variation to 8, 10, 14 or 16 rows sometimes occur.

Another class in regard to number of rows, is found in the irregularly rowed condition which is typical of the Country Gentleman sweet corn (Fig. 3). Why does this

FIG. 3—VARIETIES OF SWEET CORN

Showing the irregularly rowed condition of the Country Gentlemen variety (center ear) in contrast with the even rows of other varieties. Varieties from left to right—Evergreen, Hickox, Country Gentlemen, Crosby, Golden Bantam.

variety have irregular rows, and why do other varieties ordinarily have an even number of rows?

To explain this it is necessary to know that the corn ear botanically is thought to be a compressed and fused group of branches each bearing a series of paired spikelets along its full length. In each spikelet there are two flowers. In the even-rowed types, one of the two flowers of each spikelet degenerates leaving one to grow and form the grain thereby giving an even number of rows along the ear. In types like the Country Gentleman both flowers of each paired spikelet

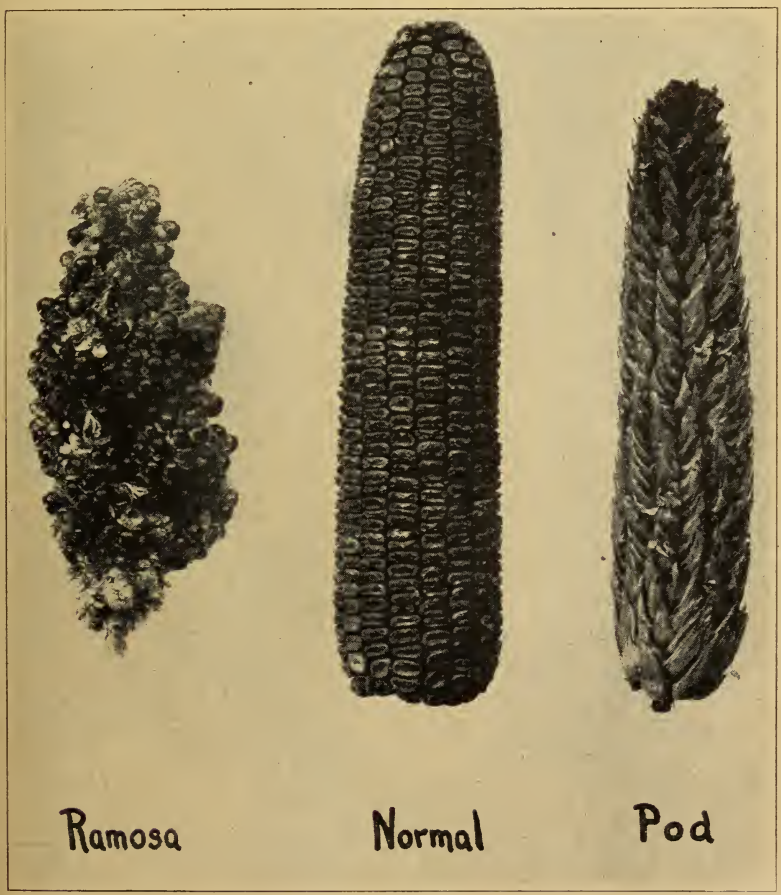

FIG. 4—HERITABLE DEFECTS IN CORN EARS

The Ramosa or branched-ear type is recessive while the pod type is dominant to the normal type.

are said to grow and accordingly become crowded irregularly on the ear.

Pod Corn. One of the off-types of ear found occasionally in field corn is one with the separate kernels entirely covered with chaff or glumes (Fig. 4). This is called pod-corn and is supposed to represent an ancestral character of corn. Except for the ear and the tassel, which is heavier and coarser than normal, a podded type of corn looks like an ordinary corn plant. This type is commercially worthless.

Branched-ear or Ramosa-ear. This is another abnormal type of ear found rarely in commercial fields. Instead of a single cob, this type has distinct branches in the ear, each bearing normal seeds as shown in the figure (Fig. 4). The tassel of a ramosa plant is quite distinct in the field and the type can be easily rogued before the pollen is shed. The side branches along the main branch of the tassel grow all the way up this central spike in a form resembling that of a spruce tree, leaving no unbranched, terminal, central spike as is the case in normal corn.

This type should not be confused with a certain abnormal ear that shows two or more short branches on the ear.

Fancy Points. In judging corn at shows there are certain general characters of the ear that are given considerable attention. Among these are soundness, maturity, trueness to an ideal type, size of ear, uniformity of ears, uniformity of kernels, type of kernels (shape, depth and space between), shelling percentage, color of cob, color of kernels, straightness of rows, shape of ear, and character of butts and tips. These various characteristics may be divided into two groups, one including useful breeding characteristics, the other including certain fancy points or show characters.

From a breeding standpoint, the following are often classed as useful; soundness, maturity, size of ear, shelling percentage, and perhaps type of kernel. Most of the other common show characters such as uniformity of ears, trueness to an ideal type, uniformity of kernels, color of cob, color of kernels, straightness of rows, shape of ear and character of butts and tips are sometimes called fancy points. Their relation to yield will be discussed in a later section.

Heredity of Grain and Ear Characters

To show how the characteristics of the ear of a corn plant behave in heredity a typical case may be taken and followed through. The system of heredity thus explained will apply in general.

Inheritance of seed-coat color. What happens when white corn is crossed with red corn, either by accident or experimentally? To test this, two crosses can be made using for example a pure strain of Silver King and one of Cardinal King, which has a red seed-coat, as follows:

a. Pure Silver King × pollen of Cardinal King.

b. Pure Cardinal King × pollen of Silver King.

If these crosses are made properly in the summer by bagging the plants, harvest time will show that the crossed ear of **a** will be just as white as the ordinary ear of Silver King and that of **b** just as red as the normal Cardinal King. In other words, the cross-pollination has not changed the color of the seed-coat in the year the cross is made. This is not strange, for the red or white seed-coat (pericarp) color was produced before pollination. It is mother tissue just as the stalks and leaves are.

However, if seeds from each of these cross-pollinated ears are planted separately the following year, all the progeny (hybrids) at harvest time will have red ears no different in appearance from the original Cardinal King. Thus a white variety pollinated by pollen from a red variety gives red hybrids and red crossed with pollen from a white variety also gives red hybrids. The reciprocal crosses give the same results, which shows that both parents contribute to the progeny equally. This is a general rule in the system of heredity. Red color is dominant in inheritance to white in this case.

Are these red hybrid ears produced by cross-pollination like ordinary Cardinal King ears? They look the same, but will they breed similarly? It is to be remembered that when pure Cardinal King is self-pollinated or even crossed by white corn, the immediate offspring are all red. This will not be true of the red hybrid ears.

The red hybrid plants produced by crossing red and white corn can be tested in two ways, (1) by self-pollinating them, and (2) by crossing them with white corn.

When self-pollinated (or inbred) and the seed grown in the following year, a definite result from the hybrid red plants is noted. The plants coming from such self-pollinated red hybrid seed show at harvest time that there are two kinds of plants. One bears red ears and the other white ears. If a hundred or more plants are counted there will be on the average about 75 percent red- and 25 percent white-eared plants.

However, if some of these same red hybrid plants instead of being self-pollinated are crossed with white corn (hybrid red crossed with pure white pollen, or even a pure white variety crossed with hybrid red pollen) and the seed grown, a different result is found. The progeny from either of these crosses shows about 50 percent red- and 50 percent white-eared plants.

Both results can be explained by the fact that the hybrid red plants are producing on the average 50 percent red- and 50 percent white-carrying eggs (ovules) as well as 50 percent red- and 50 percent white-producing pollen grains.

The result of self-pollinating the red hybrid ears is explained in Table II.

TABLE II.—SELF-POLLINATED HYBRID EARS OF THE CROSS RED × WHITE (RR × WW)

Eggs of any hybrid plant		Pollen of any hybrid plant		Progeny		
25% R	×	25% R	=	25% RR	—Pure Red	Red 75%
25% R	×	25% W	=	25% RW	—Hybrid Red	
25% W	×	25% R	=	25% RW	—Hybrid Red	
25% W	×	25% W	=	25% WW	—Pure White	

In Table II the explanation for the 75 percent red and 25 percent white progeny from hybrid red ears lies in the equal chance of red- or white-carrying eggs being pollinated by either red- or white-producing pollen. In the long run there is an equal chance of any of the four combinations, R × R, R × W, W × R, W × W. If sufficiently large numbers are grown this is most certainly found to be true.

Since red color in the seed coat is dominant to white, the three of these combinations carrying R (red) will show up as red (RR, RW, WR,) while the fourth (ww) will be pure white exactly like the original parent. It contains no trace of the red parent or red hybrid ancestor. If kept from being

crossed by red varieties, it will breed true for white color from then on.

The test of the hybrid red ears made by crossing them with a white corn is shown in the next table.

TABLE III.—HYBRID RED PLANTS CROSSED BY PURE WHITE CORN

Hybrid red produces		Pure white variety produces		Progeny	
50% R eggs	×	50% W pollen	=	50% RW	—Red
50% W eggs	×	50% W pollen	=	50% WW	—White
Pure white variety produces		**Hybrid red produces**		**Progeny**	
50% W eggs	×	50% R pollen	=	50% WR	—Red
50% W eggs	×	50% W pollen	=	50% WW	—White

Thus in either case results are identical. About half of the progeny have red and the other half have white ears. This proves that the hybrid red plants are different from ordinary red plants although they may look exactly like them. These two crosses again prove that the male side carries and transmits hereditary characters exactly like the female side. Hence the pollen of corn in breeding work cannot be neglected, for besides color it may transmit other characters like high yield, vigor, and earliness.

In general there are two kinds of the dominant type (red in this case) in heredity. One is pure like the pure variety and produces only one kind of eggs or pollen. The other is hybrid in nature and produces on the average half of one kind (red in this case) and half of the other kind of eggs or pollen.

In case of the recessive character (white in this case) there can be only one sort of plant. Accordingly when dealing with recessive characters, like white seed-coat, one can be sure that both the eggs and the pollen grains of a single plant are all white-producing (or recessive).

This in general is the system that underlies the transmission of hundreds of characters in the corn plant. It is based on the following facts:

1. That both parents contribute equally to the offspring.
2. That certain characters go in pairs, one of the pair commonly being dominant (not always completely so) and the other recessive.

3. That the hybrid between two characters of a pair contains the recessive although it may be hidden from view.

4. That the hybrid produces two kinds of germ cells (eggs or pollen) in equal numbers, one half containing the dominant and the other half the recessive factor.

5. That when pollination takes place there is an equal chance of either kind of pollen grain pollinating either kind of egg.

These breeding facts can be illustrated in another manner as follows:

Parents	Red Variety RR Eggs all R	×	White Variety WW Pollen all W
First Hybrid Generation	All RW		Hybrid Red
	Eggs 50% R 50% W		Pollen 50% R 50% W

Second Hybrid Generation (Produced by self-pollinated red-hybrids)

1 R R —25% pure red (like pure red variety)

1 R W— } 50% hybrid red (like first hybrid generation)
1 WR — }

1 WW—25% pure white (like pure white variety)

(These results are pictured in Fig. 5.)

By the use of this system of heredity definite results can be predicted and many puzzling questions explained. It is a system that works not only in plants but in animals as well. This system is known as Mendel's law of heredity. It is to be emphasized that all inheritance is not as simple as the case discussed; nevertheless this system underlies the more complex problems of breeding.

Cause of Red Ears Cropping Out in White Varieties

The question why red ears continually appear in white or yellow (colorless or white seed-coat) varieties when none are ever planted can now be answered.

The most probable reason for red color appearing in white corn is that at some time in the past, pollen from a neighboring field with a red variety (or even a single red plant in the field) has accidentally been blown over by wind and has fallen on the silks of the white variety. When this contaminated ear is harvested it is exactly as white as any other ear and may be used for seed.

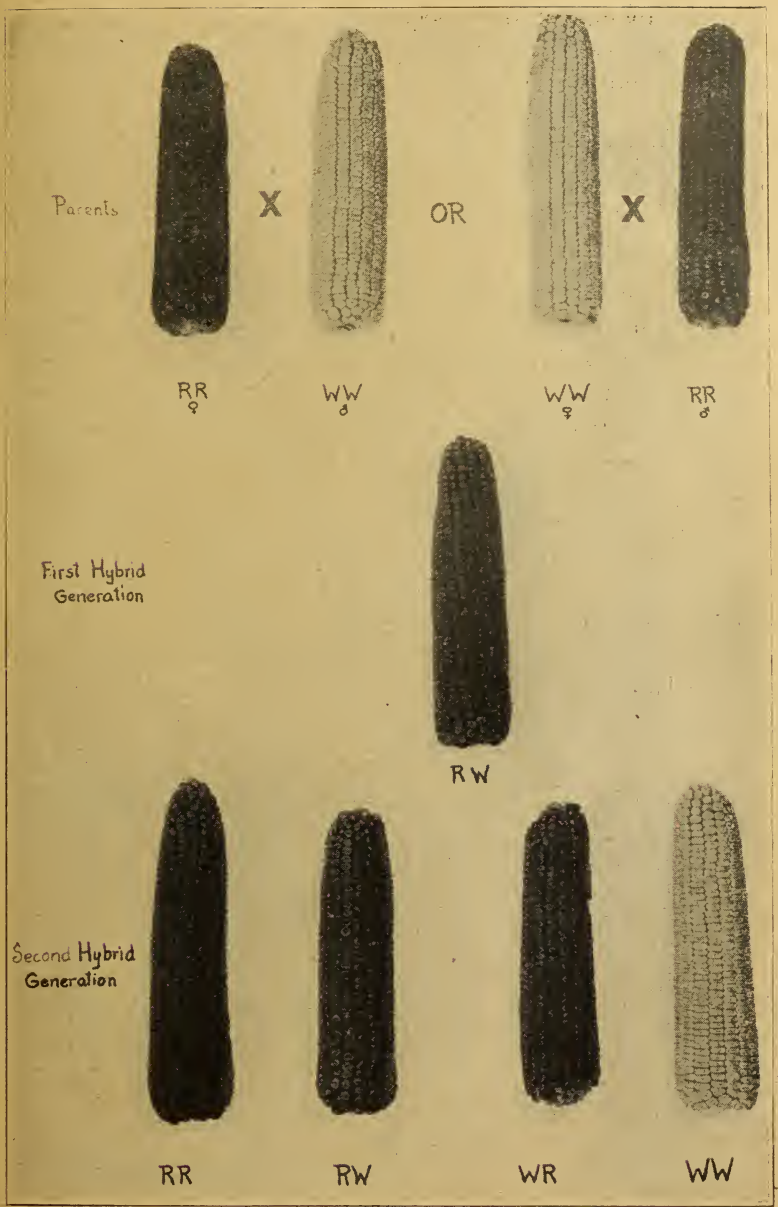

FIG. 5—THE GENERAL LAW OF HEREDITY

Crossing red and white corn demonstrates Mendel's law of heredity. The simple law illustrated here applies in the breeding of animals as well as in the heredity of the human race.

The following season however, any contaminated grains will produce red-eared plants exactly like our hybrid red plants. These will not be noticed until harvest time when they will, of course, be discarded. But meanwhile during that summer the pollen from this red plant has been blowing over the field; and since 50 percent of it is red-producing, a considerable number of white kernels of the pure white variety will again be contaminated.

Hence even though red ears are never planted, their pollen will continually spread the red color throughout the white variety. Selection will not always eliminate this off-type completely, no matter how long it is practised. Selection will gradually decrease the amount of red ears to some extent of course. The only practical method of dealing with the situation, in case the proportion of red ears becomes serious, is to procure a fresh lot of seed. It is true that by proper hand pollination and bagging seed ears of the white variety, the red color can be eliminated in one year. But such a process takes much attention and care and what is more serious introduces a certain amount of close inbreeding which may prove a handicap.

Inheritance of Cob Color

The red and white cobs of certain corn varieties follow the same system of heredity as red and white seed coat. Red cob is completely dominant over white cob.

Inheritance of Aleurone Color

Blue (or red) color in the aleurone layer of cells in the corn grain like that in Black Mexican Sweet Corn is commonly dominant over colorless aleurone.[4] It is to be remembered that aleurone color belongs to the seed showing it and not to the mother plant bearing the ear. Hence if a field of yellow or white corn is growing near a field of Black Mexican (or Blue Pop) for example, it is very likely that in the fall when the yellow or white corn is harvested, there will be a sprinkling of purple grains on some of the ears. This

[4]Rare cases are known where color is recessive to colorless (an inhibiting factor of aleurone color is present).

FIG. 6—HEREDITY OF ALEURONE COLOR

Crosses of purple and white varieties ordinarily show purple in the hybrids. In the second hybrid generation the white color reappears in approximately twenty-five per cent of the kernels.

means that those grains have been pollinated by pollen from the purple variety and are really hybrids.

Since purple color is dominant to colorless, any off-type grains in a white or yellow variety will show the contamination of color immediately and can be discarded. One can be reasonably certain that very few of the yellow or white grains in the field are crossed. For this reason, a breeder is not greatly troubled by a contamination of aleurone color.

The inheritance of aleurone color in itself is not a simple thing. It is true that in some cases when a pure purple variety is crossed by a pure white variety, the hybrid seed is purple and from these purple seeds we do get in the progeny about 75 percent of the grains on the ear that are purple and 25 percent that are colorless (Fig 6). But usually the cross shows more complexity.[5]

Inheritance of Endosperm Color

Yellow and white endosperm color follow the same simple system of inheritance that seed-coat color does with one exception. Yellow is dominant over white, but incompletely so. For example if the white Silver King variety is pollinated by the yellow Golden Glow, the hybrid seeds when harvested in the fall, are a pale yellow. If Golden Glow is pollinated by Silver King, the hybrid seeds are somewhat darker yellow but not as dark as those of the pure Golden Glow.

If the hybrid yellow seeds from either cross are planted, and the plants self-pollinated, the ears borne thereon will be identical. Both will show a certain proportion of white grains and there will be various shades of yellow kernels ranging from a very pale yellow to a dark yellow. On the whole there will be about 25 percent white grains and 75 percent of the grains will have some tinge of yellow.

If instead of self-pollinating the hybrid plants, they are crossed with a pure white variety, the resulting ears will have approximately half their grains yellow (variable) and half white. This proves that these hybrids are producing 50 percent yellow- and 50 percent white-producing eggs (or pollen grains) as was true in the preceding case in respect to seed coat color.[6]

[5]Such ratios as 9 purple to 7 colorless or 27 purple to 37 colorless are obtained which indicate that two or three factors are acting in the production of color.

[6]More complicated cases of endosperm color inheritance are known, which give 15:1 ratios of yellow and white kernels in the second hybrid generation. The variation in shade of all yellow color is caused by double-fertilization (triple fusion in the endosperm). The pale yellow cap on certain dent kernels is not explained in a simple manner.

With this knowledge the problem of accounting for white kernels in a pure yellow variety can be dealt with—a problem of every day occurence. If a pure yellow variety (dent or flint) is contaminated by being accidentally pollinated with a white type, the hybrid seeds are yellow, although in this case they are a shade lighter. This usually is not of great enough difference to prevent their being used as seed.

If they are included in the seed crop, the plants growing from them will have their pollen scattering the white color over the crop since they will be hybrid of yellow and white. And thus the contamination is spread throughout the variety and will be repeated each year. Whenever a white-producing egg (borne on a hybrid yellow plant) is pollinated by a white producing pollen grain, a pure white kernel results. The proportion of white kernels will be proportional to the number of hybrid plants in the field.

It is very difficult to eradicate white grains from a yellow variety. Careful seed selection of the seed ears, eliminating all but the dark kernels, will decrease their proportion noticeably, and will serve for all practical purposes. The presence of a few white grains does not destroy the type of the corn, although they may impair the value for show purposes.

Inheritance of Sugariness (Sweet Corn)

When sweet corn is crossed with dent, flint, flour, or pop corns, cases of simple inheritance result. The wrinkled grain of the sweet corns is recessive to the hard or smooth kernel of the other types. Not only that but the effect of the cross is seen the same year, as was the case with endosperm color. This is an everyday occurrence to anyone who has grown sweet corn for seed. There are nearly always a few starchy kernels on the ear. These come from stray pollen grains blown over from the field corn. It is very easy to remove such contamination by simply discarding these starchy kernels. If only wrinkled kernels are planted the grower can be certain that all of his corn will be sweet corn. This is true because sweet corn is the recessive character in inheritance.

If the hard or starchy kernels showing on sweet corn that has been grown near field corn are planted and the hybrid

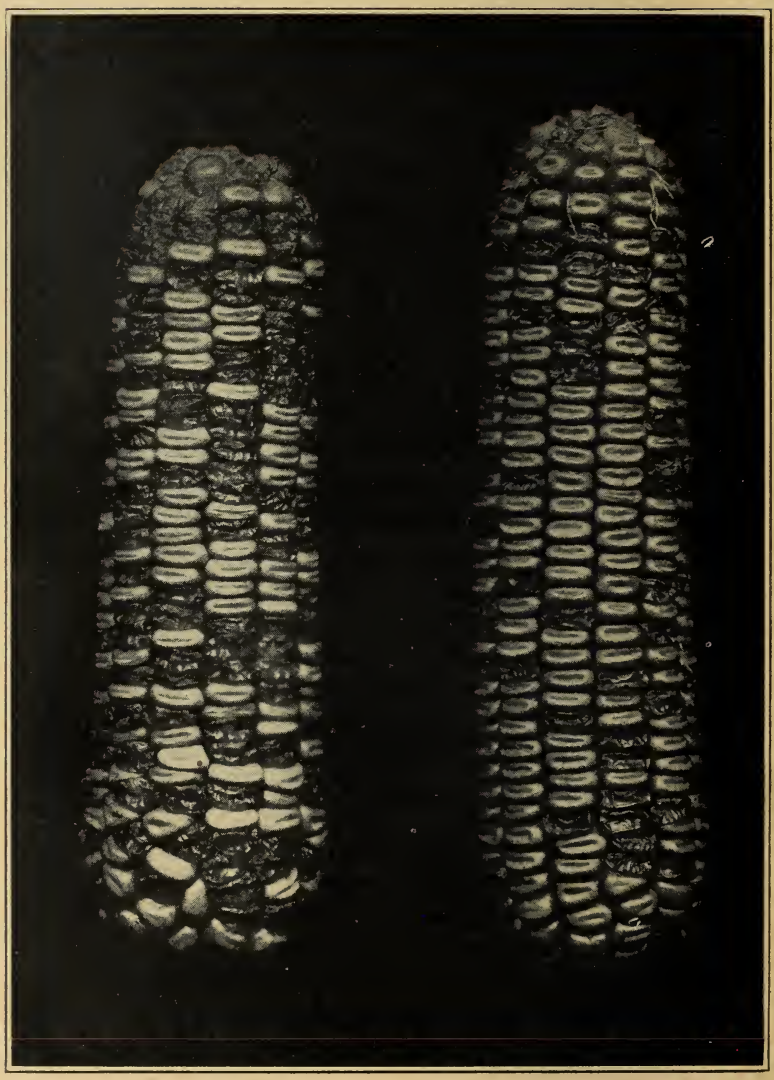

FIG. 7—CROSS-BRED EARS OF DENT AND SWEET CORN

The hand-pollinated ear to the right represents the second hybrid generation, having 7 per cent starchy and 25 per cent sweet (wrinkled) grains. Ear on left is a first generation hybrid pollinated by sweet corn, giving 50 per cent starchy and 50 per cent sugary kernels.

plants self-pollinated, there is another demonstration of the simple law of heredity. Each ear on such plants will con-

tain both smooth (starchy) and wrinkled (sugary) seeds. There will be about 75 percent of the dominant type (smooth and starchy) and 25 percent of the recessive (wrinkled or sweet) on the ear (Fig. 7.) All the wrinkled kernels will be pure sweet corn if separated and planted apart in succeeding years. This will not be true of the smooth kernels. Some of these (about one-third) will produce nothing but smooth ears if self-pollinated, while the others (about two-thirds) will repeat the 75:25 proportion of smooth to wrinkled kernels on the ear.

Inheritance of Dent, Flint, Flour, and Pop Characters

All of these types when crossed with one or other show a very complex condition of heredity. For example the hybrid between dent × flint shows very few if any visible effects of the cross the year the cross is made. The next year the plants are strictly intermediate, the kernels on the ears being all practically alike in showing a dimpled instead of a dented tip. If these are self pollinated and the seed planted, there arises in the next generation, a variety of plants with all degrees of denting, some with the deep dent of the original variety, others of a perfectly smooth flint type, but most of them intermediate in denting. The same is true in general of dent × pop and flint × pop crosses. When flour corn is crossed by dent, flint or pop there is still another type of inheritance which cannot be dealt with here.[7]

Inheritance of Defective or Abortive Endosperm

This is one of the new characters that the plant breeder has discovered lately by means of his pedigreed work. It is found in practically all types of corn and is one cause for poor ears. It is an hereditary thing and if once it gets into a variety it is very difficult to eliminate even if care is taken in sorting the seed.

Defective or abortive grains are recessive in inheritance. For this reason they are not numerous in ordinary corn, because the cross pollination usually brings in the normal or

[7]This case is dependent on triple fusion in the endosperm together with the fact that a double dose of either flour or of hard starch is dominant to a single dose.

dominant character. Hence they may be in a corn variety and be overlooked until that variety is inbred closely, when they will crop out in sufficient numbers to destroy the looks of the ear. When this happens it is time to get a new stock of seed from some reliable source.

The continued contamination of abnormal grains is brought about by planting hybrid seeds which look exactly like normal ones. The plants from such seeds produce normal-appearing plants that spread 50 percent of the defective-carrying pollen to other plants.

Inheritance of Number of Rows

It has been noted that with the exception of the Country Gentleman variety, the corn ear normally shows an even number of rows. When an 8-rowed type is crossed by a 16-rowed type the result is not a case of simple inheritance.

There is no complete dominance of the rows of either type. The hybrid plants will show ears with an intermediate condition. The great majority will be 12-rowed, with some 10- and 14-rowed. If any of these are self-pollinated and grown another year, a variable lot of plants with respect to number of rows will be procured. If large numbers are grown, plants with 8, 10, 12, 14, 16, or perhaps even 18, 20 and 22 rows will be found. The majority will be 12-rowed, there being less of the 10 and 14-rowed ears and still less of the 8, 16, 18, 20, or 22 rowed ears.

The explanation for this is rather complex and cannot be treated here. The inheritance of row number is not due to any one heritable factor but probably to a great number, each of which follows the same simple system of heredity.

This complexity explains in some measure the lack of uniformity in the best of our varieties in the matter of number of rows on the ear. Even in the most carefully bred varieties, especially in the dents, there is always a great variation in this respect, and we cannot hope to produce a uniform variety by ordinary methods of breeding. As is explained later it is perhaps not advisable to breed for such strict uniformity.

Inheritance of Pod Corn

The striking thing about the inheritance of pod corn is that it is one of the rare abnormal types in corn (of which there are scores) that is dominant to the normal sort of ear. If ordinary corn is pollinated by pod corn, and the seed (which will be perfectly normal) planted, all the hybrid plants will have the podded-kernels.

When these are self-pollinated and the seed grown the following year, there will be approximately 75 percent podded plants and 25 percent normal plants. The latter if self-pollinated will breed true for the normal condition and will never throw any podded plants if their pollination is guarded.

Inheritance of Ramosa or Branched Ear

The real branched-ear type is inherited in a simple manner, being recessive to the normal ear. If it appears in a commercial field it is difficult to eliminate since certain normal-appearing plants always carry this character and spread it around through their pollen, 50 percent of which is ramosa-producing pollen.

Corn Seedlings

The appearance of white or yellow seedlings is one of the commonest sights in the corn field after planting time. They occur in nearly every large field, sometimes only one or two; but sometimes as many as 10 percent of the seedlings are white or yellow. They are found in the best bred varieties. For example, a first prize (Iowa) Reid's Yellow Dent selection in 1917 showed in a 50 acre field about 1 white seedling to every 2,000 green ones by actual count.

They occur in every type of corn and have been found in dent, flint, pop and sweet varieties in varying amounts from .0001 percent under field conditions to 44 percent in inbred varieties. (See Table 4)

The writer has by means of inbreeding isolated fully 300 strains of dent, flint, pop, and sweet varieties which produced about 25 percent white, greenish-white or yellow seedlings. Some of these are shown in Fig. 8.

TABLE IV.—ACTUAL FIELD COUNTS OF WHITE SEEDLINGS[8]

Year	Variety	Acres	Percentage of white seedlings
1917	Country Gentleman	½	12.0 %
1918	Reid's Yellow Dent	4	1.0 %
1918	Reid's Yellow Dent	35	.1 %
1919	Reid's Yellow Dent	45	.09%
1919	Reid's Yellow Dent	210	.06%
1919	Dent Corn	35	1.60%
1919	Dent Corn	400	.05%
1920	Reid's Yellow Dent	780	.07%
1920	Evergreen Sweet	2	1.00%

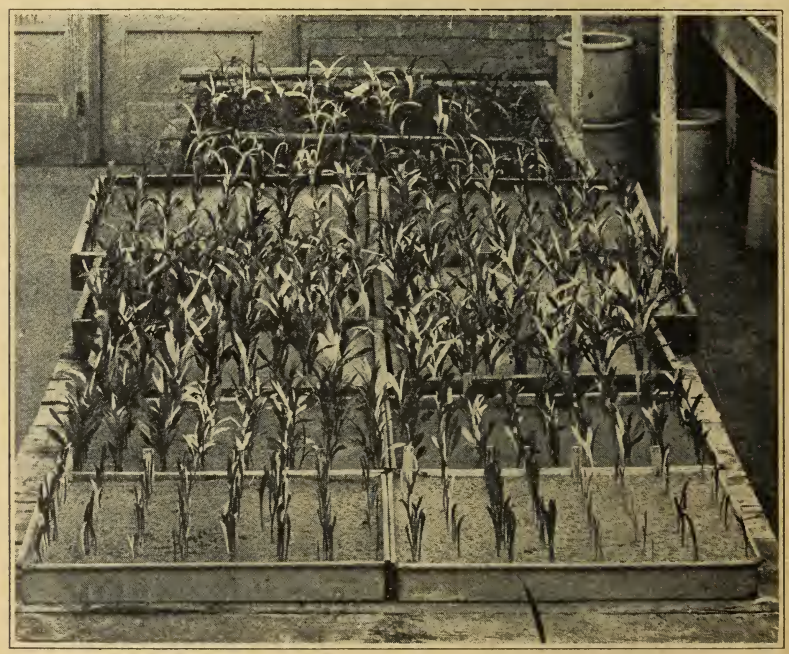

FIG. 8—ALBINO CORN SEEDLINGS

Greenhouse plantings from inbred corn showing large percentage of white or albino seedlings. These are not due to poor soil or insect injury but to definite hereditary factors.

Guesses as to the cause of white seedlings include such things as sick-soil, cut worms, wire-worms, plant diseases (chlorosis), poor seed and many others. As a matter of fact, probably none of these causes is concerned. It is true that

[8]Data furnished by Dr. W. H. Davis from a study made in Iowa.

wet soil will often cause a yellowing of the seedlings, but this should not be confused with ordinary white seedlings which appear directly alongside normal, green ones in the best of soil.

That neither soil conditions, insect injury nor diseases are the cause of these abnormal seedlings has been abundantly proven. They have been produced at will in the soils of Nebraska, New York, and Wisconsin both in the field and in the greenhouse; in natural as well as in sterilized soil. By means of pedigree cultures, the white seedlings can be produced at will, and the proportion of them predicted with considerable accuracy.

All this means that the causes for such abnormal seedlings are carried in the seed as a part of the plant. They are hereditary, exactly like white rabbits or albino persons.

White (or yellow) seedlings are recessive to normal green ones just as sweet corn is recessive to starch (flint or dent) corn. Despite the fact that they die off in the seedling stage as a rule and do not even shed pollen they are not eliminated. Certain green plants (hybrids) are tainted with this white "blood." These are constantly forming 50 percent of their pollen and 50 percent of their eggs with white-producing factors. Such green plants look no different from ordinary green plants and their ears are just as likely as not to be selected for seed. In this way the contamination keeps on from year to year.

Unless the white seedlings are very numerous (over 8 percent) it is useless to worry about them. They die off and merely leave a little more space for the normal plants which can then produce a trifle better ears. If they become too numerous it is advisable to discard the seed and secure a fresh lot.

Dwarf Plants

Another striking abnormality which sometimes crops out when corn is closely inbred is the dwarf type (Fig. 9). When mature the dwarf plant is approximately one and a half feet tall. It produces pollen and small ears regularly. The reduction in growth of a dwarf plant is mainly conditioned by

FIG. 9—NORMAL AND DWARF STATURE IN CORN

Two mature corn plants illustrating hereditary dwarfness. The dwarf plant produces good pollen and small ears. There are many different types of dwarfness like this.

the shortness of the internodes, since it has practically as many nodes and leaves as a normal plant.

Dwarfness in corn is recessive in inheritance. The hybrid plant between dwarf and tall is just as tall as any normal plant. When self-pollinated such a hybrid will produce, in the next year, an average of three talls to one dwarf.

Striped Plants

Occasionally a corn plant with white, yellow, or light green stripes in the leaves is seen in a corn field. Most of these are hereditary. They are recessive in inheritance exactly like the dwarf type. The same is true of a peculiarly yellow or "Golden" type of plant. None of these abnormal types of plants occur often enough in commercial corn to cause any real damage.

Barren Stalks

In every corn field, no matter how good the variety nor how well handled, there will be found barren stalks and plants bearing only nubbins. In some fields as many as 25 percent of the plants are unproductive. It is a fact that these things are for the most part hereditary. True, some of the nubbins are caused by poor conditions of pollination and certain growth factors, but they form only a small part of the unproductive plants. It is also true that too thickly planted corn produces poorly developed ears. Despite these conditions a considerable percentage of unproductive plants are caused by poor heredity.

That they are hereditary is easily proved in our inbreeding work with corn. Some inbred rows will be absolutely free of barren stalks while others growing alongside have a very high proportion of them.

Selection of good ears borne on good plants in the field is the only practical method of gradually decreasing the percentage of barren stalks. Since they sometimes produce a small amount of pollen, it is very difficult to rogue them out completely.

Earliness

It is possible to select for an earlier strain of corn in the average variety because ordinary varieties of corn are variable enough to afford a basis for selection of earliness (or lateness) of maturity. Such selections should be made in the field just before harvest time when the husks are beginning to turn brown.

There is only one danger in this selection and that is a very serious one. Avoid selecting prematurely early ears, especially those that are borne on prematurely dead stalks. The chances are that such stalks are abnormal or diseased. It is very easy to mistake such plants for early-maturing ones. Never select ears, no matter how good, from leaning or broken stalks, nor ears with slightly rotted shanks. These are all likely to be diseased. Choose the ears that show early maturity from vigorous, erect stalks. In combining earliness with yield (size of ear) be careful not to choose a plant which is vigorous because it has had no competition, being the only plant in the hill. The chances of this good yield being transmitted to the progeny are very small.

There is a danger in selecting for too early a type. Such a type may not take advantage of the full growing season. One should aim to select corn that will mature shortly before the average first killing frost in the fall.

Inbreeding

Inbreeding or very close breeding to type in corn has not proven to be a good thing. This can be proved by self-pollinating (the closest form of inbreeding) any of the best plants in a good variety. The progeny will, in nine cases out of ten, be inferior in height, vigor and yield (Fig. 10.) This is equally true of sugar beets, cabbage or cotton. It is not true of wheat, oats, peas, beans, or barley, or any other of our naturally self-pollinated crops.

The writer has inbred or self-pollinated over ten-thousand corn plants in his experience. Among these have been included the best varieties of dent, flint and sweet corn. In practically every instance the progenies have been noticeably weaker; in none have they been consistently much better than the parent. Such inbreeding has produced in the progeny all

FIG 10.—EFFECTS OF INBREEDING IN CORN

Two rows of corn. The one on the left has been inbred for three years; the other is a cross of two relatively poor inbred strains. Inbreeding is used to eliminate defective characters. The inbred strains are then outcrossed to restore vigor.

sorts of abnormal and weak types, including albino seedlings, barren stalks, dwarf plants, striped plants, twisted stalks, crinkly leaves, defective kernels, light yellow-green plants, branched ears and scores of other defects. These have come from our best varieties of corn. The variety and proportion of poor corn plants that crop out when inbreeding is practised even in the best varieties is surprising.

The reason these defective types do not show up in any noticeable proportion in ordinary corn is because these characters are recessive in inheritance. The normally cross-fertilized corn plant prevents many of such recessives from getting together in one plant or in one kernel. The normal type, being dominant, masks the effect of the recessive, poor types.

If close selection to a narrow type is practised we tend to approach the practice of inbreeding to some extent. The closer the selection the nearer to inbreeding. Consequently to avoid it, it is necessary to sacrifice a little on uniformity to get yield and vigor in return. The corn breeder must realize this sooner or later for it is based on experimental fact and years of experience.

Hybrid Vigor

One of the most striking facts of corn breeding is that hybrids or crosses between two types or varieties of corn are likely to give a progeny that is superior to the better of the parents. Not all crosses of types or varieties give such increased vigor and yield but some do. Closely related selections, strains or varieties give less increase as a rule, than those further removed. For example a cross of two yellow dent varieties will show less superiority over the parents than some crosses of dent by flint. This means that relationship is a factor.

Unfortunately this increase in vigor and yield does not hold up in the next year or later. The progeny from these vigorous hybrids splits up again into a very non-uniform lot of plants whose average yield is likely to be 15-20 percent lower than the hybrid lot.

The commercial use of hybrid vigor is a much debated question. If the right combination of varieties can be secured and if the temptation to use the seed from the vigorous hybrid can be prevented, there is some possibility of its commercial application. Of course, the crossed seed must be provided each year, a fact which requires a certain amount of additional labor.

This method is not advocated as a general procedure by the experiment station, and probably should not be for some time, at least until the average farmer has become more

familiar with corn breeding. With the campaign on for pure seed it is probably impossible to send hybrid seed out over the state, and expect the average farmer to refrain from planting it the second year. If he does this, his own crop and his neighbors' are likely to be ruined by the resulting cross-pollination. This method is safe only in the hands of the specialized corn breeder—one who can impress on his buyers the all-important fact that such cross-bred corn seed must be procured anew each year.

Show Characters

Corn growers know that the prize-winning ears in a corn show do not always produce the best yields. It is also true that the progeny from such prize ears do not always repeat closely the ear type of the prize mother ear. Can it then be said that show characters are of little actual use in corn breeding?

The best and only real test of the yielding power of an ear of corn is the test of its progeny. This method is not practicable for the average farmer since it means too much extra work. Is there any way in which the yield of corn can be predicted by looking at the seed ear?

Scientific corn breeders have tested the correlations between yield and such show characters as length of ear, width of ear, shape of ear, shelling percentage, number of rows, filled tips, rounded butts and a good many others. They have found practically no relation between yield and those characters. For example such tests showed that tapering ears yielded as well as cylindrical ears and that ears with poorly filled tips yielded as much as those with filled tips. Accordingly these characters should be classed as fancy points since they have no direct relation to yield.

Nevertheless the seed ear does give the breeder a general idea of what the progeny will be like especially in relation to adaptibility to the locality. The maturity of the ear indicates the adaptibility of the variety to the conditions under which it was grown. A sound, well-dried, hard ear means that the variety will stand up under the average conditions of the particular locality. The color of the kernels will indicate whether or not the variety is reasonably pure. A slight mix-

ture of yellow and white kernels is not a serious draw-back from the standpoint of yield. It does mean, however, that the mixture will continue to become worse each year if left alone, and the general type of the variety may gradually become broken if proper selection is not practised.

The size of the seed ear is fairly important, although size of ear does not reproduce itself very exactly. It is better to be on the safe side however and plant only from the medium sized or larger ears. The depth of kernel is important since it is a factor in shelling percentage. Here again it pays to play safe and plant only seed ears that have a reasonably deep kernel, especially if they mature well in the locality. Shape of ear, filled tips or well rounded butts and other fancy points, are minor factors and are to be taken less into consideration.

All told it will probably pay to select seed ears that common sense shows to be good for the purpose desired. "Like begets like" to a certain extent and this principle holds true in a general way.

Methods of Corn Breeding

While the method of ordinary selection is advocated for the general farmer and grower of corn seed, there are several other systems of corn breeding that are somewhat more complicated.

The ear-to-row method is based on the idea that the best test of yield is the test of the progeny of an ear. Ordinarily a large number of selected ears are tested. The more ears the greater chance there will be of getting the best. The seeds from each ear are planted in a separate row and the rows duplicated or triplicated in different parts of the field if possible. At harvest time each row is husked separately and the weight and other characters of the harvested corn recorded. The ears from a few of the best rows are usually chosen to plant a seed plot the following year.

This method does not take into consideration the male parent, the sire of the ears. The mother ear may have been a good ear, but its seed may have been planted near a row from a poor ear. Thus the good quality coming from the mother ear may be partially destroyed by the pollen from the poor sire.

To avoid this possibility the ear-remnant system of breeding was planned. According to this method, a large number of selected ears are chosen. About one-half of the seed of each ear is planted in one or two separate rows. The ears and rows are so marked that one can trace the progeny-row of each ear back to the mother ear. Yields are taken of each row.

Instead of using the seed from the best rows of this ear-to-row test, the remnants of the mother ears producing these best rows are sorted out and used to plant the seed plot the following season. In this way the best yielding ears are selected and the possibility of their being crossed with poor ears is avoided.

Still another method of improving the yield of corn is to take advantage of the fact that hybrid seed between some varieties is likely to give an increased vigor and yield. It has been proven experimentally that when certain varieties are crossed, the first-generation hybrids give an increased yield over the better parent. Not all variety crosses give a sufficient increase to justify crossing them. This has to be tested experimentally.

To get a large amount of crossed seed it is necessary to grow the two chosen varieties in a small isolated seed plot (probably about ½ to three acres, depending upon the amount of seed wanted.) One variety is detasseled before any of the silks in the plot come out. The other variety, which is used as the sire or pollen parent, is left alone. For practical purposes this sire need be planted only in every third or even in every fifth row. The wind blows enough pollen to the intervening mother rows to produce a good set of seed.

In the fall, only the seed from the detasseled rows is harvested for seed corn. This should be carefully dried and stored. It is then ready for planting in the following spring. During that season the crop will undoubtedly show a high degree of uniformity and a good yield.

But if seed is saved from this field there will be a serious drop in yield and uniformity the next year. To use the idea of the increase in yield of hybrid seeds, it is absolutely necessary to produce this seed anew each year; or better to produce enough seed one year for two years' planting.

At the present time it does not seem advisable to advocate this method of corn breeding for the general farmer. Sufficient tests of the best varieties to cross have not yet been made in Wisconsin.

The latest attempt to improve corn is also too new to advocate for the general farmer. This consists of inbreeding strains of corn (by hand-pollination) for several years. This inbreeding isolates the poor types and they can be eliminated.

After several years of inbreeding, followed by proper selection, most of the off-types are eliminated. Then the best inbred strains are crossed to produce greater vigor and yield since both of these qualities are lost to some extent by inbreeding. It will require a large amount of careful work to follow up such a system and its practicability is still a question.

However, for the average corn breeder who does not wish to experiment, the most practicable method of maintaining quality and possibly of effecting some improvement is the one of ordinary selection. Selection of good seed ears in the crib is less effective than field selection. The breeder must get out into his seed field just before harvest when the ear husks are beginning to show brown. A large number of the best looking ears borne on the best plants are harvested and then husked and dried. In the field selection, those plants that are lodged, prematurely brown, poorly colored, with poor tassels, with smut or with any other disease or abnormality should be avoided. After husking the ears any poor ones can be discarded. It is possible to save corn seed for two years (even three years if properly stored). Accordingly it is wise to select enough seed for several years. This is especially true if frost is likely to destroy the seed crop in any one year.

IMPROVEMENT OF CORN by modern genetic methods is too complicated to be practicable for the general farmer, but must be left to the special plant breeder or trained seed grower.

In the future the specialist will probably be depended upon very largely if not exclusively for the production of new varieties and possibly for the growing in large quantities of definitely cross-bred seed for commercial use. The general corn grower will continue to use the ordinary methods of selection to maintain the purity and quality of his grain if he is raising his own seed; or the time may come when he will find it more profitable commercially, on account of increased yields, to use cross-bred seed which he would purchase each year from special seed growers.

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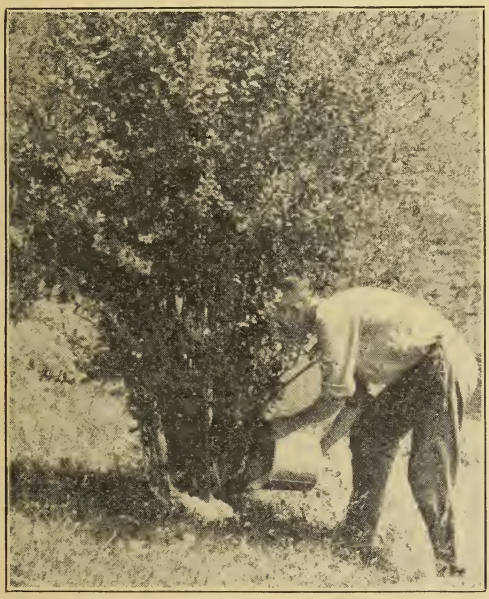
Ag. Serials

State Department (Agr. Exp. Sta. Bul. 357) May, 1923
Bulletin 55

Fighting Black Stem Rust of Grain by Eradicating the Barberry



STATE DEPARTMENT OF AGRICULTURE

Division of Insect and Plant Disease Control
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The cities and villages of Wisconsin have been surveyed for barberry and practically all bushes have been pulled out. Resurveys are necessary because suckers start readily from the broken roots. Furthermore, the surveys have shown that the barberry is much more widely distributed than was first thought, and in several instances it has escaped into pastures and woodlots and has multiplied into the millions. While complete eradication, at the present rate of progress, will require a number of years, it is thoroughly worth while.

Intensive farm-to-farm surveys are being conducted in the southern half of the state at the present time. This work is correlated with similar work in northern Illinois, Iowa and Minnesota so as to make as large an area as possible that is "barberry-clean." Many hedges and individual barberry bushes have been located in this way that otherwise would have escaped attention and continued to be a menace to the grain-growing interests.

At the end of 1922, there had been found in Wisconsin 3,354,155 dangerous barberry bushes of which 2,788,936 had been removed. More than half of all the barberries found in the 13 states working under the eradication plan have been located in Wisconsin, showing that this state is a large center of infection and indicating the necessity of continued close cooperation between farmer, townsman, and inspectors to make the campaign the success that its importance merits.

The United States Department of Agriculture, the State Department of Agriculture and the College of Agriculture are cooperating in the barberry eradication, the federal government having supplied the major portion of funds to defray field expenses. Five publications on barberry eradication have been issued by the United States Department of Agriculture; namely, Farmers' Bulletin, 1058, entitled "Destroy the Common Barberry;" Department Circular 188, entitled "Progress of Barberry Eradication;" Separate from Yearbook No. 796, entitled "The Black Stem Rust and the Barberry;" Department Circular 269 entitled "Barberry Eradication Prevents Black Rust in Western Europe;" and Department Circular 268 entitled "Kill the Common Barberry With Chemicals." These may be had free on request from the Secretary of Agriculture, Washington, D. C., or Commissioner of Agriculture, State Capitol, Madison, Wis.

Fighting Black Stem Rust of Grains By Eradicating the Barberry

By

NOEL F. THOMPSON AND JAMES G. DICKSON*

The black stem rust of wheat, rye, oats and barley is being controlled in Wisconsin by eradicating the common barberry (*Berberis vulgaris* L.). Information gained since 1918 has shown that the early stem rust outbreaks each year are due to a general spread of rust from the barberry to these grains early in the spring. The spores blown in from other more distant areas do not develop rust on these grains until after the danger of damage from rust has passed. In other words, the barberry in Wisconsin has been found to be the source of early stem rust outbreaks on wheat, rye, oats and barley.

Commendable progress has been made in destroying the dangerous, common barberry in Wisconsin, but many bushes still remain. The surveys made since 1918 have shown that the barberry was much more widely distributed in Wisconsin than was at first thought possible. In many localities the shrub has escaped from cultivation and is growing wild in pastures and woodlots. It is necessary, therefore, that if effective control of stem rust is to be obtained, the campaign for barberry eradication must be continued until the escaped as well as cultivated bushes are destroyed.

Heavy Losses Caused by Black Stem Rust

Black stem rust of wheat, rye, oats, and barley causes heavy losses of these crops each year. It is a disease produced by a minute plant called a fungus. This fungus grows within the grain plants in a manner somewhat similar to the way the grain plants grow in the soil. Growing in this way, the fungus takes its food and moisture from the grain plant on which it is growing, thus robbing the plant of the food which should normally go to the head to form plump, heavy kernels. In addition, the rust fungus growing in the plant breaks the outer layers of the stems and leaves and allows a large amount of water to escape. (Fig. 1.) Badly rusted plants, as is well known, produce greatly shrunken or shrivelled grain of light weight and poor quality. (Fig. 2.)

While it is difficult to estimate the losses caused in this way by black stem rust, yet the annual reduction in yield from this cause is

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very great and in years when severe and widespread rust epidemics occur the entire crop is damaged. In the United States, the reduction in yield of wheat alone varies from 800,000 bushels as estimated for 1918 to 180,000,000 bushels as estimated for 1916. The estimated

FIG. 1.—THE STEM RUST SPLITS THE SURFACE OF THE STEM AND LEAVES

The stem rust appears on the leaves and stems of barley, oats, wheat, rye and some grasses.

average loss of wheat for the five years from 1916 to 1920, inclusive, is about 64,000,000 bushels each year.

While Wisconsin is not one of the chief wheat-producing states, the total production of small grains places Wisconsin high in the list of grain-producing states. For example, in 1922 Wisconsin produced 102,000,000 bushels of oats, 14,000,000 bushels of barley, 7,000,000 bushels of rye and 3,000,000 bushels of wheat, a total of 126,000,000 bushels of small grains. As the losses from stem rust on all of these cereals is high in Wisconsin, the state is vitally interested in the control of stem rust.

FIG. 2.—THE STEM RUST CAUSES SMALL HEADS AND BADLY SHRIVELED GRAIN

The wheat heads shown at A were collected near a barberry bush where the rust was very heavy. The heads are small, the straw is poor, and the grain is light and shriveled. The head shown at B was from a portion of the field free from rust. The heads are large, the straw is clean, and the grain plump and heavy.

Black Stem Rust Has Strange Life Story

The development of black stem rust makes a very interesting story. The rust usually makes its appearance on the grain about the last of May in Wisconsin, as a brick-red pustule or spot on the stem or leaf. (Fig. 1.) A close examination of this red pustule shows it to be filled with a fine powder—the spores or "seeds" of the tiny rust plant. If these spores are shaken or blown by the wind to other similar grains

and are given sufficient moisture and warmth they grow and develop rust on those plants also. The growth of the rust plant is so rapid that it takes only a week or ten days from the time the spores fall on one of the grains until new spores are produced, as evidenced by the

FIG. 3.—THE STEM RUST FORMS CLUSTER CUPS ON THE LEAVES OF THE COMMON BARBERRY

The cluster cups of the spring stage of stem rust appear on the under surface of the common barberry leaves and spread spores to the surrounding grains and grasses. The large cluster cup on the right is magnified in Fig. 6.

production of the red pustules. This process may be repeated over and over again as long as the grains on which the rust plant grows remain green and the weather is favorable. Enormous numbers of these spores are produced. The red dust seen occasionally during the

harvesting of the grain is composed entirely of these spores of the rust fungus, and each spore is capable of spreading the disease.

When the grain begins to ripen, a change takes place in the rust. Red spores are produced no longer, but in their place heavy black spores are formed. (Fig. 1.) These black spores differ from the red spores in both color and habit, for they cannot produce rust on other grains but serve to carry the rust plant over the winter. They readily live through conditions of cold and wet which the red spores cannot withstand. It is only under the most favorable conditions that any of the red spores are able to survive the winters in Wisconsin. Indeed, there are records of only two such cases. So if the rust plant is to survive the winter it must depend on the black spores. These germinate in the spring on the stubble or old straw and produce tiny color-

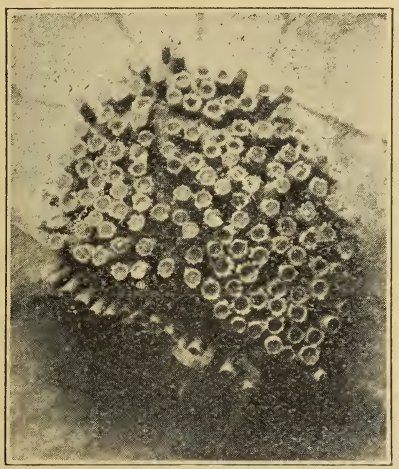


FIG. 4.—CLUSTER CUP OF THE STEM RUST ON BARBERRY HIGHLY MAGNIFIED

Each little cup contains spores enough to sow stem rust on an acre of grain. There are spores enough on the whole cluster cup to spread rust over a 40-acre field.

less spores which are blown about by the wind. If these fall on growing grain, they are unable to produce rust and soon die. They also die if they fall on the soil, but if they light on a common barberry and gain entrance to its young growing parts, they live and produce thrifty little rust plants.

Millions of the black rust spores live over the winter and each produces several of the tiny colorless spores in the spring, but all of them die except the few which happen to fall on a common barberry and penetrate it. On the barberry leaves yellow patches are formed by the rust (Fig. 3) and from these patches, (Fig. 4 and 5) yellow spores spread the rust back again to the grain, producing the red rust pustules on the stems and leaves. This completes the life story of the black stem rust.

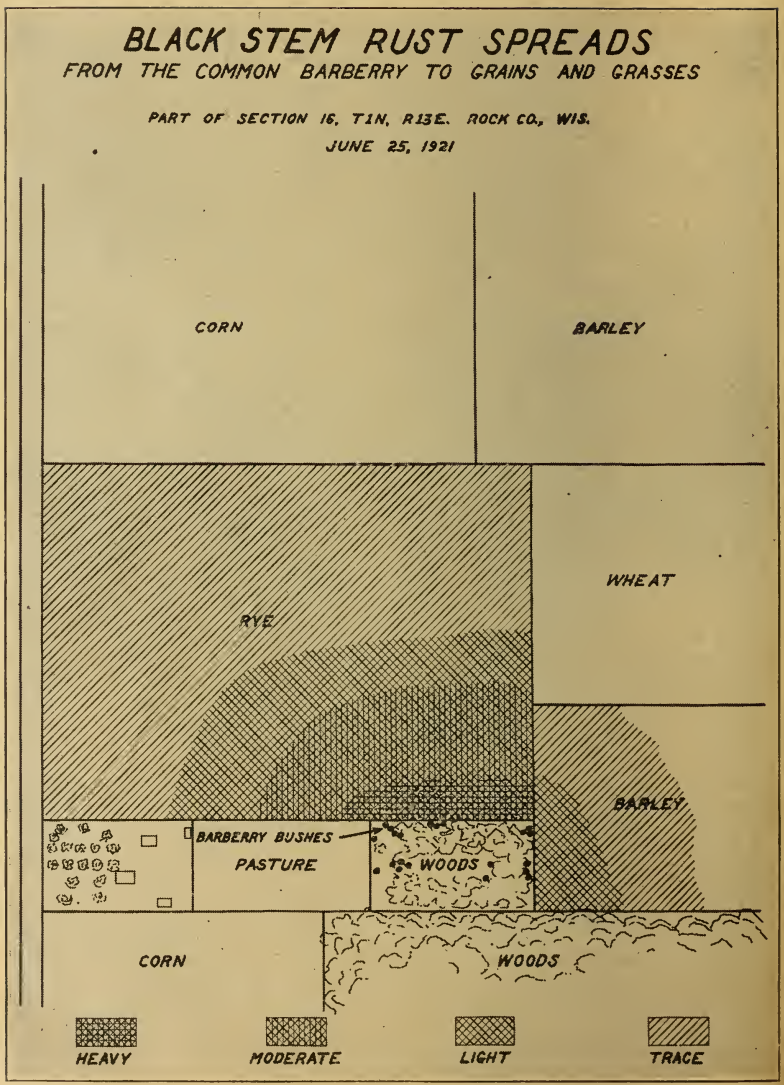


FIG. 5.—SPREAD OF RUST FROM THE BARBERRY

Map showing the spread of black stem rust from common barberry bushes growing wild in a pasture and wood lot on Section 16, Township 1 N, Range 13 E, Rock County, Wisconsin, in 1921. The density of shading shows the severity of the rust infection on rye and barley. Notice that the wheat was not rusted indicating that only the rye-barley strain of rust was present.

Thus do we see that there are three different forms in which we may find the black stem rust. During the early part of the summer we have the red form on the grain. This spreads the rust from one grain plant to the next. As the grain ripens the black form develops and this is able to live through the winter on the stubble and straw and to infect the barberry in the spring, producing the third or yellow form of the rust. From the barberry the rust returns to the grain only in the spring.

Different Strains of Stem Rust

The black stem rust of all the grains is caused by the same species of rust fungus, which is named **Puccinia graminis**. There are, however, several so-called specialized strains of the fungus each capable of attacking only a limited number of grains and grasses. For example, the stem rust strain of rye, barley, quack grass, and certain other grasses cannot attack wheat or oats. (Fig. 5 and 7.) The stem rust strain on wheat attacks wheat, barley, squirrel-tail grass, and certain other grasses, but cannot attack rye or oats. Similarly, the stem rust strain on oats attacks oats and certain grasses but cannot attack rye, wheat, or barley. Barley is the only grain that is subject to the attacks of more than one of these stem rust strains, for both the rye and wheat strains may attack barley. On the other hand, barley is the only grain which does not have a stem rust strain specialized chiefly on itself.

All of these various specialized strains of black stem rust can infect the common barberry in the spring by means of their black spores. And then in turn, each strain can spread from the barberry back to the same grain or grains and grasses to which it is specialized. That is, the specialization remains the same, even after infecting the barberry; so that if the rust on the barberry came from black spores produced on oats it could return to oats but could not cause rust on wheat or rye. This explains many cases where rust has attacked a field of one kind of grain and not neighboring fields of other cereals.

There Are Two Types of Rust on Grains

In addition to black stem rust, or "black rust" as it is frequently called, there also are leaf rusts which occur on the various grains. These leaf rusts are often confused with black stem rust. They are, however, entirely different and are caused by other species of rust fungi. These leaf rust fungi do not attack the barberry nor do they usually cause serious losses of grains in Wisconsin.

Leaf rusts usually can be distinguished from black stem rust by their position on the grain plant and by the size and shape of the spots they produce. The leaf rusts occur only on the leaves and leaf sheaths of the grain, and the spots produced are quite small and usually round. Early in the season these spots are filled with an orange-yellow, powdery substance, but later in the summer they may appear grayish-black. The black stem rust, on the other hand, develops on both the leaves and the stem of the grain. The spots are long and filled with

a brick red powder or, later in the summer, with a black powder. The skin of the grain plant breaks and curls back from the rust spot. This is the rust which causes the most severe damage to the grain and also attacks the common barberry.

Relation of the Common Barberry to Stem Rust in Wisconsin

The life story of the black stem rust as just outlined in the previous paragraphs varies considerably in different sections of the United

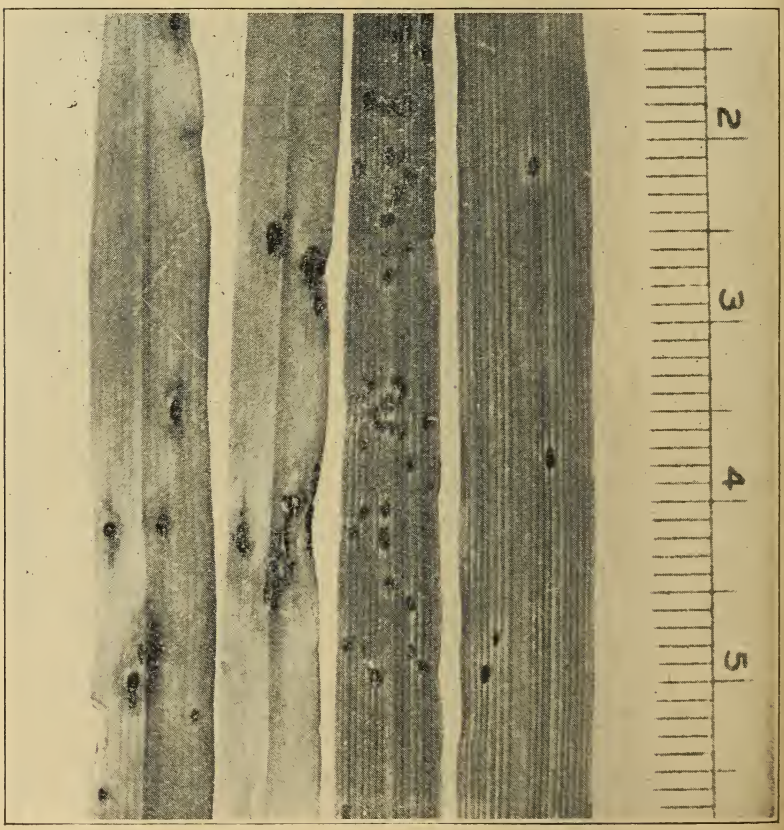


FIG. 6.—THE STEM RUST AND LEAF RUST ARE DIFFERENT

The stem rust on the leaves of winter rye (left) causes long lesions and splits the surface of the leaves. The leaf rust (right) causes small round lesions and does not split the leaf surface.

States. In Wisconsin and throughout the central and north-central sections of the United States, the red rust spores or summer spores are killed during the winter and early spring by the cold weather and by freezing and thawing, thus the rust lives over chiefly in the black rust stage and must go through the barberry to again rust the grains.

Thousands of samples of rust collected in the field in Wisconsin and in the adjoining states have been tested for germination during the winter and spring each year from 1918 to 1922. While these red rust spores germinate and are capable of producing rust on the grains until late in the winter, they generally die during late winter, and early spring, or become too weak to rust the grain plants. The average of the germination tests, given in Table I, shows the limited amount of germination that occurs as spring and the new growing season approach. Though apparently each year some of the red rust spores lived over winter in a few locations, no new rust developed at any of these stations during the following spring. Quantities of the red rust spores were taken in from out-of-doors during the late winter and sown on the same grains growing in the greenhouse but produced no rust. Therefore, while some of these spores germinated, they were evidently too weak to produce rust on the new spring plants.

TABLE I.—THE AVERAGE PERCENTAGE GERMINATION OF THE RED RUST SPORES OF THE BLACK STEM RUST.

Plant on which rust occurred	Average percentage germination of red rust spores for each month						
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Wheat	24.2	12.8	2.0	0.0	0.1	0.0	0.0
Rye	32.9	1.7	1.7	0.0	0.2	0.0	0.1
Oats	30.2	9.3	1.9	0.6	0.1	1.1	0.1
Average	29.1	7.9	1.9	0.2	0.1	0.4	0.1

While a few of the red rust spores in protected places live through the winter especially during very mild seasons, the majority of these spores die fairly early in the winter, October and November. In addition to the red rust spores being killed by the winter exposures, the rust plant in the wheat leaves dies as the wheat leaves attacked by stem rust rot very easily under the snow during the winter months.

In only two instances in Wisconsin has rust been found which had spread the following spring from the red rust stage living over winter. The spread of rust from these plants has been very slow and decidedly limited. For example, a field of winter wheat on the university farm was heavily rusted with the red rust stage of black stem rust late in the fall of 1919. Of the thousands of wheat plants heavily rusted during the fall, only one plant was found in a sheltered place in the field in the spring of 1920 on which the red rust had lived over winter. This plant was found early in April while the barberry leaves were yet in the bud. The plant was marked and all adjoining plants carefully watched for the spread of rust. The last week in April new rust was found on the newer leaves of this plant and on three plants in contact with this plant. On May 30, when the rust was spreading in large quantities from the common barberry to the adjoining grain fields, no

new rust had developed on these plants. At heading time, the rust had spread from this one plant to the lower leaves of some of the plants four to eight drill rows away and at harvest the rust had spread scatteringly over one edge of a late planting of Marquis wheat but too late to do any damage to either the winter or spring wheat.

The red rust which over-winters is always close to the ground on the fall leaves and is protected by the growth above it. On the other hand, the rust which develops on the barberry is out where the wind catches the light spores and spreads them long distances to the grains and grasses. Thus the spread of rust in the first case is near the ground and limited while in the latter case the rust spores from the barberry are carried long distances by the wind and settle down on the tops of the growing grains.

The rust develops on the barberry in Wisconsin in early May and begins spreading rust to the grains and grasses soon after the middle of May. The following table gives the dates at which the barberry has rusted, the dates rust spread to grains and grasses, and the general stage of development of winter and spring grains at the date of rusting.

TABLE II.—THE STAGE OF DEVELOPMENT OF GRAINS AND THE DATE OF SPREAD OF RUST FROM THE BARBERRY.

Season	Date barberry rusted	Date rust found on grain	Stage of development of grain	
			Winter	Spring
1918	May 11	June 6	Shooting	Tillering
1919	May 18	June 10	Heading	Tillering
1920	May 23	June 12	Heading	Tillering
1921	May 1	May 30	Shooting	Tillering
1922	Apr. 29	June 2	Heading	Seedlings

It is evident from the above table that in Wisconsin the barberry is the important factor in the early and general spread of stem rust to the grains. This season for example the barberry was rusted and ready to spread rust to the grains almost before the spring grains were out of the ground or the winter grains had started growing. The barberry was ready to spread rust on May 5 before rust had been reported even in the extreme southern wheat sections.

The barberry spreads the rust over the adjoining grain fields and wild grasses producing an early rust infection which then spreads from plant to plant in the field causing total losses in the vicinity of the bushes and heavy losses over an area of several miles from the bush.

Figure 6 is a map showing the early spring spread of rust from the barberry to winter rye and spring barley. The rust spread from the barberry out over the fields causing a heavy rust attack near the barberries and a light spread over the surrounding fields just previous to the heading of the winter rye. The rust two weeks later had spread from plant to plant and at the time the rye was in the soft dough stage

was bad over the entire field. At this time a light sprinkling of rust was found generally throughout the entire county. Likewise the rust on the barley had spread from field to field causing damage to this crop. The barberry, then, spread the rust to the winter rye in May and ruined the crop in the field adjacent to the bushes; it then spread from field to field over a considerable area but fortunately weather conditions were not favorable for a rust epidemic or this would have

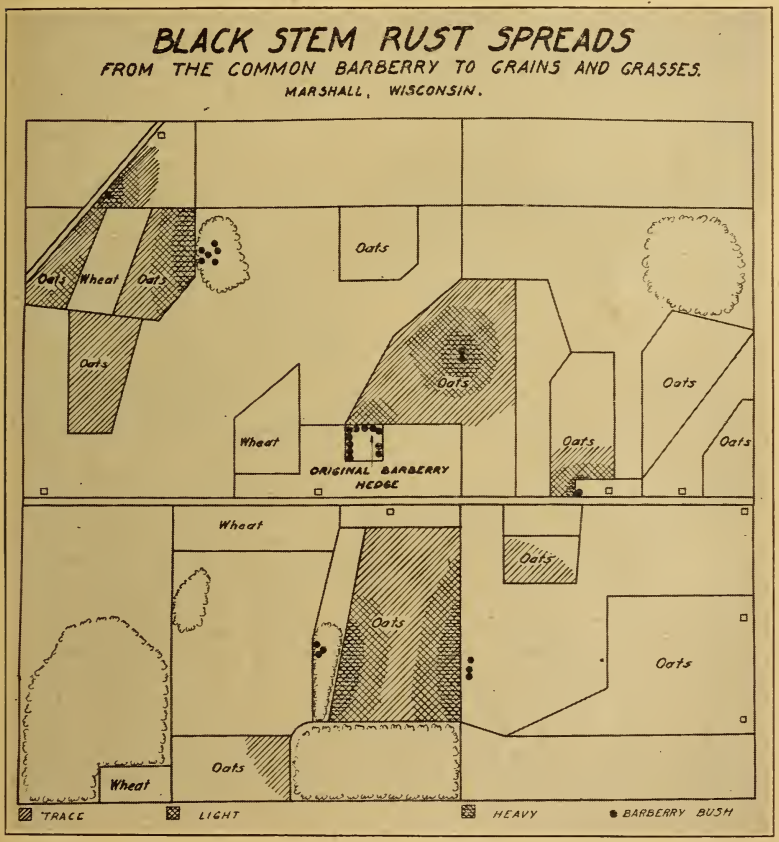


FIG. 7.—SPREAD OF RUST FROM THE BARBERRY

Barberries were scattered by birds and cattle from the hedge shown near the center of the map to nearby woodlots and fence rows. The map illustrates how the rust had spread from these escaped barberries to the grain by July 1, 1922. Notice that the wheat was not rusted indicating that only the oat strain of the rust was present.

been one of the centers from which rust spreads like wildfire over the northern states early enough to catch the grain while filling and destroy the grain crop. Such general epidemics occurred in 1916, local ones occurred in 1919, and if weather conditions are favorable, there are still barberries enough in the state to cause an epidemic this season for the rust is waiting for the spring grains to come up.

A clear cut example of the influence of the barberry on the development of stem rust was found in LaPorte county, Indiana. Only one barberry planting has been reported in the county and the farmers in this section had been troubled year after year with stem rust. The rust was even so severe in the vicinity of the barberry planting that wheat growing had been abandoned. The county agent working with the farmers cleaned the barberry bushes out of this pasture and killed all of the sprouts. The following spring they planted wheat in the fields adjoining the pasture and watched closely for stem rust. The fields all developed a full crop with no trace of stem rust, whereas in the previous seasons the yields were reduced by over one-half. Wheat has been grown on these fields since and no stem rust has developed. Wisconsin, this season, will have regions entirely free from the barberry which will give the same results.

In the two instances where the rust has been found overwintering on the grains and grasses, the spread of rust has not occurred until in July, which is too late to greatly damage even the late spring grains. The spread of rust from the barberry, on the other hand, has for the past three years occurred before June first, early enough to ruin both winter and spring grains if weather conditions are favorable for a rust epidemic. The eradication of the barberry in Wisconsin, therefore, will check the general spread of rust to the grains and retard all spread until the grain crops are safe from rust. For the grain growers all know that a rust epidemic before or while the kernels are filling means a heavy loss, whereas the same rust epidemic coming ten days later means little or no loss.

The stem rust in Wisconsin overwinters in the black rust stage and then rusting the barberry in the early spring spreads to the grains and grasses. Occasionally however the rust overwinters in the red rust stage on the grains and grasses and in addition it may spread into the northern states from the gulf states where the red rust spores overwinter without great difficulty. While the rust spores are carried long distances by strong northerly winds, especially in the great plains region, the detailed survey the past two seasons has shown conclusively that rust in the northern great plains region and especially in Wisconsin from such a source does not reach the grain crops early enough to cause heavy losses. For example, in the spring of 1921, the barberry in Wisconsin was spreading quantities of stem rust to the adjoining grain fields June 1. At this date no rust occurred in the south, north of the southern boundary of Kansas. The general light spread of stem rust which might have been attributed to the spread of rust from the south did not occur until late in June. Again in 1922 the barberry was spreading rust May fifth, almost before the spring grains were out of the soil and no stem rust had been found north of northern Texas.

While the rust undoubtedly does overwinter in the red rust stage in protected places and under favorable seasonal conditions in Wisconsin; and while it undoubtedly spreads into the northern states from the south as the season advances, the rust in Wisconsin from both of these sources reaches the winter and spring grains too late to cause an epi-

FIG. 8.

THE DANGEROUS BARBERRY THE HARMLESS BARBERRY

The tall barberry (left) helps to spread stem rust, is dangerous and should be destroyed. The low Japanese barberry (right) is harmless and may be grown.

demic and serious loss even under very favorable weather conditions. The spread of rust from the barberry on the other hand occurs early in the spring each year and results in a general development of stem rust, always damaging the grains near the barberries, and occasionally spreading in epidemic form over the entire state and northwest.

Different Kinds of Barberries

There are many species of barberry. Some are native in certain sections of the United States but fortunately only a few of these species become rusted, and there are no native barberries in Wisconsin or the adjoining states which carry the black stem rust. Not all even of the introduced barberries carry this rust, so it is necessary to distinguish between those that do and those that do not. The varieties that have been most commonly planted are the common green barberry *(Berberis vulgaris)*, the common purple barberry *(Berberis vulgaris purpurea)*, and the Japanese barberry *(Berberis thunbergii)*. (Fig. 8.) Of these three, the first two are equally dangerous as spreaders of stem rust of all the cereals and they should be destroyed. The

FIG. 9.—THE COMMON BARBERRY AND THE JAPANESE BARBERRY, SHOWING THE DIFFERENCES

Leaves: Fairly large, with saw-tooth edges.
Spines: Long, and usually in groups of three.
Berries: In clusters like currants.

Leaves: Rather small, with smooth edges.
Spines: Fairly short and usually single.
Berries: One or two together.

Japanese barberry, on the other hand, does not rust and is entirely harmless. This is fortunate, as it is a beautiful shrub and is largely used in ornamental plantings.

These plants are easily distinguished, as is indicated in Fig. 9. The green and purple varieties are almost identical except that one has green leaves and the other has reddish-purple leaves. As these plants are not native to our state they are not ordinarily found growing wild in the woods but should be looked for among the shrubs planted around houses and on lawns. In a number of places, however, the common barberry has escaped from cultivation in Wisconsin and has spread extensively in pastures and woodlots. If this spread were not being checked by the Barberry Eradication Campaign, it might soon have been as impossible to eradicate the barberry from the state as it would be to eradicate the Canada thistle.

Some other varieties of barberry as well as some varieties of mahonia also carry the black stem rust but, as very few of these have been planted in Wisconsin, it is hardly necessary to describe them. The barberry law covers all such plants and in case any question arises as to the nature of any particular plant it would be well to send a specimen to Madison to the Agricultural Experiment Station or the State Department of Agriculture for identification.

History of the Barberry

Barberry a Native of Asia

The common barberry is neither native to Wisconsin nor to the United States, but is believed to have come originally from western Asia, where it is still found growing wild in the Himalaya mountains. One of the earliest records of this plant is in the Babylonian writings of about 650 B. C., where it is mentioned as being of medicinal value. Like many other Asiatic medicinal plants, it was carried by man wherever civilization advanced and possibly was introduced into Europe in this way. Even during the eighteenth century, it was very highly prized by the doctors of Europe and the alleged virtues of the various portions of the plant are described in detail. When we recall that the medical men of that day had to raise their own plants and make their own drugs to a very large extent we can understand why the barberry came to be planted in every village and town.

During the latter part of the eighteenth century and in the early part of the nineteenth, the common barberry came into favor as a hedge to separate fields. Its rank, rapid growth and its long sharp thorns made it excellent for this purpose. As the bushes became abundant and large crops of berries were produced, the juice of the fruit found a ready use as a beverage and also in the making of jellies and preserves. So, in many places, we find the bushes planted in gardens as are currants and gooseberries.

Introduced Into the United States by Early Settlers

The common barberry seems to have been one of the first plants brought to America by the early New England settlers and there are accounts of the use of barberry jelly as a medicine in the latter part of the seventeenth century. By 1700 it had become firmly established in the New England states, and, since that time, wherever the New Englanders have moved they have taken the barberry with them. As many of the early settlers of Wisconsin were from New England, it is not surprising that their log cabins became the centers for the spread of the barberry in this state.

The Barberry Was Brought to Wisconsin Many Years Ago

One of the earliest plantings of which we have record was on the farm of John Hilton, who patented a half section of land near the city of Madison in 1836. These plants thrived and became wild, spreading

extensively throughout the woods south of Lake Mendota. Another record is of barberries near Baraboo planted by David Wells, who brought them from Vermont in 1856. There are many similar records. Hence, it is evident that, even though the plant is not a native of Wisconsin, it has been in this state for almost a century. Not all the

FIG. 10.—CITIES AND VILLAGES OF WISCONSIN IN WHICH COMMON BARBERRY BUSHES HAVE BEEN FOUND

Note the widespread occurrence of this bush.

plants came from New England, however, for we find that S. B. Lueders, a botanist, brought bushes from Germany in 1852 and planted them near Sauk City, and that John Meidam brought bushes from Holland in 1853 and planted them near Appleton. Other bushes were brought from England about 1850 and planted near Manitowoc, and still others came from Switzerland.

At the present time it is very difficult to trace the history of most of the early plantings in this state, but enough has been given to show that the barberry was introduced many years ago and that where the bushes are now found growing wild they have simply escaped from cultivation. In more recent years the nurseries sold thousands of both the green and the purple common barberries in Wisconsin for use as ornamental plants. This was stopped in 1918 when the Barberry Eradication Campaign was started.

ERADICATION OF THE BARBERRY

Early Attempts at Eradication

The harmful effect of the barberry on grain crops is not a new discovery and the eradication of this bush to save the grain has been attempted many times. About 1805, what has been called the "Barberry War" broke out in parts of Europe and particularly in Denmark. As has been said, it was about this time that the bush had found favor as a hedge to separate fields but the farmers soon learned that where it was so used they could raise an abundance of straw but no grain. That this bush was in some way responsible for the poor crops was soon recognized and many hedges were destroyed. However, as many people raised the plant for its supposed medicinal value and others used the fruit in making wine and jellies, the bushes were not all destroyed and the records tell of groups of angry farmers who armed themselves and made raids on the bushes of neighbors who had refused to destroy their barberries. One instance is told of a village judge who had some common barberries and refused to permit their destruction, although all the others in the district had been removed. For many years the farmers were unsuccessful in their efforts to eradicate these plants, but the day after the death of the judge in 1839 they armed themselves "with spades and axes" and "before evening came the bushes were spread on the earth." They were then burned "amidst song and jubilee."

During this "war," laws against the barberry were passed in parts of Germany, France, and Denmark, and laws have since been passed in other European countries. Today there are laws against the common barberry in practically all European countries and it is extremely difficult to find any of the bushes in the agricultural sections of the continent.

In the United States, laws against the barberry were enacted in Connecticut, Rhode Island, and Massachusetts between 1726 and 1766. In Connecticut and Rhode Island, these laws were renewed after a

period of years so the results must have been satisfactory. They did not exterminate the barberry, however, and today it is found growing wild very extensively throughout New England, so that its eradication would be extremely difficult, if not practically impossible.

Recent Successful Eradication

The first successful eradication campaign was carried on in Denmark. In 1903, a law was passed requiring the destruction of all harmful barberries in that country, and by 1910 practically all bushes had been destroyed. The results were striking. Previous to 1903, severe rust epidemics with heavy losses had been common but since the bushes have been destroyed there has not been a single epidemic and very little rust has been found. In most cases such rust as has been found has been traced to some barberry that had been overlooked.

The Eradication Campaign in the United States

States Pass Laws Against Growing the Barberry

American scientists, as well as farmers, had long recognized the possibility of controlling stem rust by the removal of the barberry but concerted action was not possible until the increasing frequency and destructiveness of rust epidemics throughout our northern wheat-growing states made some action imperative if wheat, and especially spring wheat, was to continue to be grown. In 1918, the United States Department of Agriculture, in cooperation with thirteen of the northern wheat-growing states, extending from Ohio and Michigan on the east to Colorado, Wyoming and Montana on the west, started a campaign to remove all harmful barberries from this territory. Laws soon were passed in all these states forbidding the propagation of common barberries and all other varieties known to carry rust.

The following is an extract from the Wisconsin State Law and is typical of the laws passed in all the states interested in this campaign:

Section 96.38. HARMFUL BARBERRIES, ERADICATION OF. (1) No person shall receive, ship, accept for shipment, transport, sell, offer for sale, give away, deliver, plant or permit to exist on his or its premises any harmful barberry, or any plant of a species that shall be designated by the department of agriculture in published regulations to be a host or carrier of a dangerous plant disease or insect pest.

(2) The state entomologist may destroy any such plant found growing in the state. If the owner shall refuse or neglect to eradicate such plants within ten days after receiving a written notice so to do, the expense of such eradication shall be certified to the town, city or village clerk and assessed, collected, and enforced against the premises upon which such expense was incurred as taxes are assessed, collected, and enforced, and shall be paid into the treasury of the state.

(3) The term "harmful barberry" shall be interpreted to consist of any species of Berberis or Mahonia susceptible to infection by Puccinia graminis, commonly called black stem rust of grain, but not including Japanese barberry, B. thunbergii.

98.48. PENALTY FOR VIOLATIONS; PROSECUTIONS. Any person violating any provision of sections 96.33 to 96.47, inclusive, or any rule or regulation promulgated under the authority of said sections, shall be fined not less than twenty-five dollars nor more than five hundred dollars for each offense.

Immense Numbers of Barberries

It was thought at first that very few barberries would be found, but four years' work has disproved this idea. Comparatively few of these

FIG. 11.—MAP SHOWING RESULTS OF FARM-TO-FARM SURVEY

The dots indicate the location of farms on which barberries were found in the 26 southern counties where the survey has been completed.

bushes were found in Montana, Wyoming and Colorado, but as we progress eastward the numbers increase rapidly, and the magnitude as well as the seriousness of the undertaking becomes apparent.

At present, Wisconsin leads all the other states in the number of bushes found and consequently in the magnitude of the work necessary to free herself from this pest. Not only are the common barberries found growing in the planted shrubbery in the cities, but many a farm boasts a beautiful bush in its front yard! In the counties in the southern part of the state which have already been surveyed (Fig. 11) there were an average of about 70 farms per county having barberries. Unfortunately this bush thrives in our climate and on many

FIG. 12.—A HEDGE OF COMMON BARBERRIES PLANTED AROUND AN ORCHARD

The hedge of common barberries spreads rust to the neighboring grain fields causing immense losses each year.

farms barberry seeds, scattered by birds and cattle, have taken root spreading the plant along the fences and into the pastures. At first the farmers thought little of the danger to their fields. Some tried to cut out the bush but where one plant was cut down a dozen grew from the broken roots and it soon became apparent that, as a weed, the barberry was as hard, if not harder to kill than the Canada thistle.

This was a new and unexpected development and one which has increased the seriousness of the problem many fold. It is evident that, had the barberries been left to spread but a few years longer, the task of eradicating them would have been insurmountable and many other-

wise valuable and productive fields would have been over-run and made valueless by this aggressive weed, as has already occurred in the New England states. What effect this would have had on the wheat and other small grains of the state is problematical.

Barberry Very Difficult to Eradicate

The barberry should be destroyed immediately, both on account of the danger to the cereals and the imminent danger of its becoming a serious and widespread weed in this state. But this is not as easy as one might wish and it is on just this account that it is so dangerous. It is a shallow-rooted plant, most of the roots lying within six inches of

FIG. 13.—THE PROPER WAY TO REMOVE BARBERRY BUSHES

Dig deep enough to get all of the roots out with the plant to prevent sprouting. Heavy canvas gloves protect the hands.

the surface of the soil but spreading to a considerable distance in all directions. Even with careful digging, these roots are seldom removed entirely but are broken off, leaving portions in the ground. These portions almost invariably sprout and produce thrifty young plants which soon replace not only the one that was removed but add a large number of new ones. By continued watchfulness and repeated digging, it is a fairly simple matter to remove a few bushes from around a house, but where there are thousands of bushes scattered over pastures and woodlots and along fence rows, it is not so easy.

The old bush can be easily removed by digging, by use of a team or tractor or a stump-pulling outfit, or by blasting. All these methods are in use, the one chosen depending on the size and number of the bushes, the character of the soil, etc., but with the greatest care some roots are always left in the soil and the spot must be revisited a second and a third time.

Experiments are under way to find the best and cheapest method of killing the barberries. Numerous chemicals have been studied and two are recommended for use. These are salt and sodium arsenite solution. The salt is used dry. About ten pounds piled in the center

FIG. 14.—SPROUTS OF THE COMMON BARBERRY IN A WISCONSIN PASTURE

The bushes were cut off two different times and each time sent up a new lot of sprouts.

of an average size bush will kill it. Sodium arsenite is made into a dilute solution containing the equivalent of about eight pounds of white arsenic (As_2O_3) per barrel of water. Two gallons of this solution poured around the base of a barberry will effectually kill an average size bush. It acts best when the ground is relatively dry and the weather warm. More detailed directions for the use of these chemicals can be found in circular 268 of the U. S. Department of Agriculture.

Present Status of the Campaign in Wisconsin—Cities and Villages Freed From Barberries

The Barberry Eradication Campaign has been under way in Wisconsin since April, 1918. The first move was to find and remove all dangerous bushes from the cities, parks and nurseries, for from these the bushes are carried into the country. The accompanying map (Fig. 10) shows the villages and cities where barberries were found and removed. It should be noticed how widely the bush was distributed throughout the state.

The number of bushes found and the number of properties are given in a table on page 27.

FIG. 15.—THE COMMON BARBERRY GROWING WILD IN A PASTURE

The barberry has escaped into pastures and woodlots; where once established it becomes a serious weed.

Country Districts Still Have Many Barberries

When the cities and villages were fairly free of barberries attention was directed to the country districts and at present the survey is proceeding county by county. This work was started in the southeastern corner of the state and is progressing westward and northward. It is necessary to visit and inspect every farm, for many people do not know the bush and a few are selfishly refusing to destroy their barberries until ordered to do so by an inspector. Consequently, with the limited funds available, the work is going slowly, but it is progressing, and when a county has been gone over in this manner few or no barberries remain.

The accompanying map of the southern portion of the state (Fig. 11) shows the territory that has been covered in this farm-to-farm survey and the approximate number and location of the farms on which barberries have been found. More exact data are given in the table on page 27.

Wild Barberries are a Serious Menace

A third phase of the campaign and one which is assuming even greater importance is that of barberries which have escaped from cultivation, a problem which has previously been mentioned. Such wild bushes already have been found in over 82 areas throughout the state and as the campaign progresses many more undoubtedly will be found. In some cases there were but one or two bushes, but in others the bushes had already spread over an area several miles in extent and the farmers were beginning to realize their destructiveness as a weed entirely apart from their effect on the grain. The aggressive character of this "weed" may be realized by the experience of one farmer in Grant county. He has a wooded pasture of about 300 acres in which the barberries had secured a firm foothold. When visited by an inspector, this farmer said he had been digging out the bushes as fast as he found time for several years and estimated that he had removed about 5,000. It was evident, though, that he was not even keeping up with the spread of the barberry. In 1920, a crew of men was employed and about 35,000 large plants, besides a very large number of small ones, were removed from this pasture. In 1922 another crew of eight men went over this pasture, carefully digging all sprouts and removing many small bushes which had been missed previously. The pasture is still far from being free of barberries, however, as many small plants still remain and more sprouts will develop. There may also be many seeds which have not yet germinated. The danger may be better realized when it is added that the original hedge from which all these wild bushes came was planted by this farmer only about thirty years ago!

Present Status of Barberry Eradication in the United States

There are thirteen states engaged in the eradication campaign. Because, in most of these states, the complete eradication of the common barberry will require from five to fifteen years at the present rate of progress, the work has been planned so that the clean area in one state will join with the clean areas in the neighboring states. For instance, North Dakota, South Dakota, and Nebraska have worked on their eastern borders, while Minnesota and Iowa have worked on their western borders thus making a continuous strip of territory from Canada to the southern edge of Nebraska and Iowa free from barberries. Likewise, Wisconsin started on the south and Illinois on the north. In 1922 Wisconsin connected with a clean area on the northern edge of Iowa and the southern edge of Minnesota, making a continuous strip of territory nearly free from barberries from Lake Michigan to South Dakota.

The plan of the work has been similar in the different states though the territory covered varies considerably in extent at present. The area covered in the farm-to-farm survey in Wisconsin is small when compared to the areas covered by some of the other states, though in actual numbers of bushes found and eradicated she is first. The very fact that very large numbers of wild barberries have been found in this state has slowed up the work tremendously. Some of the other states have also given much greater financial assistance to the work than has Wisconsin. The Minnesota legislature up to 1923, for instance, has given more than ten times the financial aid to this work that the Wisconsin authorities have been able to give.

The following table shows the number of properties on which barberries were found in each of the thirteen states, as well as the number of bushes found and removed.

TABLE III.—SHOWING THE RESULTS OBTAINED IN THE BARBERRY ERADICATION CAMPAIGN FROM APRIL 1, 1918, TO DECEMBER 31, 1922.

State	No. of properties from which bushes have been removed	Total number of barberry bushes found	Total number of barberry bushes removed
Colorado	1,639	24,001	23,822
Illinois	9,085	142,882	129,786
Indiana	3,923	96,284	94,004
Iowa	8,365	764,096	761,227
Michigan	6,490	265,109	221,090
Minnesota	4,611	778,997	776,803
Montana	196	9,027	8,680
Nebraska	3,153	88,862	88,180
North Dakota	731	19,438	19,438
Ohio	5,402	230,088	210,438
South Dakota	739	52,309	47,302
Wisconsin	7,580	3,354,155	2,788,936
Wyoming	78	4,140	3,841
Total	51,992	5,829,368	5,173,547

SUMMARY

The presence of the dangerous barberry in the vicinity of grain fields gives the black stem rust a "running start" in the spring. This has been observed many times since the barberry eradication campaign was started in Wisconsin in 1918.

The black stem rust fungus overwinters on grain stubble and on many grasses. In the spring, in May or early June, when the barberry leaves are coming out, spores are carried by the wind from the stubble, and rust starts on the barberry. Within a week or ten days it develops on grains and grasses and spreads like "wild fire" if the weather is warm and moist. Spores from stubble will not infect young grain nor will those from barberry spread rust to barberry. Therefore, the removal of the barberry takes out an important link in the chain of development and so slows up the early spring start of the rust that most grains are able to ripen a crop without danger from a rust epidemic.

The barberry is a native of Asia but was brought to Europe at an early date and came to this country along with the early settlers. It was widely planted as a quick-growing, ornamental shrub whose yellow roots were thought to have medicinal value.

In common with 12 other states in the upper Mississippi valley region, Wisconsin has passed a law condemning the dangerous barberry. The state entomologist or his deputies are empowered to inspect any property they think necessary and to order removed or to remove at owner's expense any dangerous barberry. Fortunately the Japanese barberry does not harbor rust and need not be removed.

75 b

Bulletin 358 October, 1923

UNIVERSITY OF ILLINOIS

Drainage District Farms in Central Wisconsin

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN IN COOPERATION WITH
THE WISCONSIN DEPARTMENT OF AGRICULTURE

Drainage District Farms In Central Wisconsin

E. R. Jones, B. G. Packer

THE DRAINAGE DISTRICTS of central Wisconsin date back at least fifteen years. The early systems of drainage were faulty and failed to provide adequate ditches. Failure to care for the ditches in some districts made poor drainage worse. The Little Yellow, Cranberry Creek and Portage County Drainage Districts have realized that their early ditches were too shallow. They have deepened them to an average of eight feet and have put in some new ditches. This has meant further assessments of taxes against the land in addition to the original assessment for drainage. In these districts there is no land more than half a mile from a ditch. Some of the other districts are contemplating supplementary construction.

At the time of organization much of the land was controlled by speculators and was then and is now offered as trading property. There has been no definite plan of settlement or agricultural policy. Until lately no effort was made by the districts to exhibit samples of their crops at fairs or expositions.

The value of peat has been questioned. A great deal of money has been spent by farmers who insist that it did not produce as they expected it would from its appearance. Some have brought suits to break their contracts of purchase. Others who bought too much land and equipment too elaborate for a beginner fell down because they could not carry the investment and pay the extra cost of supplementary drainage needed, in addition to the regular drainage tax of the district. Still others failed to give the marsh land a square deal because of shiftless farming and persistent unwillingness to follow suggestions.

The point has now been reached where the question naturally arises whether it is wise or economically sound to organize more drainage districts on new areas in these counties. The answer is "yes" where there is need of more tillable acres on the surrounding unland farms dipping down into the marsh. It is "yes" where a sound and decently enforcible utilization plan is made a part of the drainage plan. But it is emphatically "no" in all other cases. Let wise utilization catch up with the outlet drains already constructed.

In order to give full, frank and competent information on the successes and failures of marsh farming to all settlers on the marsh and those contemplating peat-district location the following stories of success or failure have been told by the farmers themselves.

As Told by the Farmers

Table 1 is the result of interviews with 87 representative farmers. The list does not include all the farmers in the drainage districts visited but an effort was made to see and talk with every farmer in the portions of the districts covered.[1]

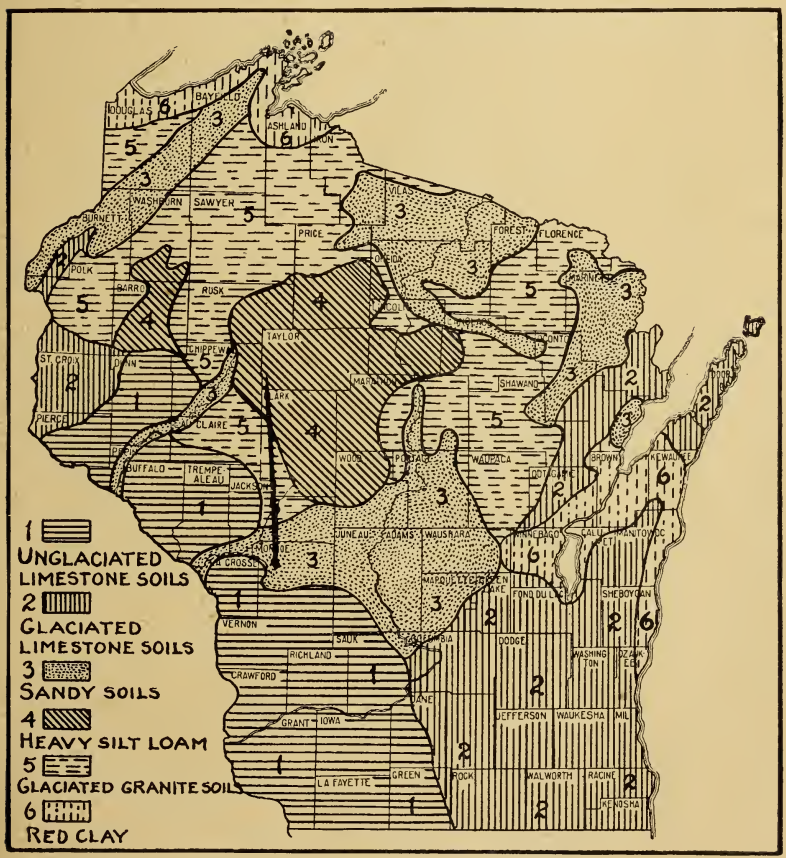


FIG. 1—SOIL AREAS OF WISCONSIN

The names of the farmers are not given but will be furnished upon application. The farmer was encouraged to talk freely of his successes and failures. Part of what he had to say was jotted down while walking through the field; some of it while he was doing his chores; and much of it was written on the supper table after the dishes were out of the way. These farmers want more neighbors, but do not want them to

[1]The statements of the farmers were obtained through personal visits by the authors and in some cases in company with a representative of the Bureau of Drainage Investigations, United States Department of Agriculture, S. H. McCrory, Chief.

Marshes, Drainage and Farms

The nine counties starred in central Wisconsin contain 505,394 acres in 16 drainage districts in which 854.9 miles of outlet ditches are operating. These districts are under the direction of the circuit judge, who acts through three commissioners. The outlet drains, costing about $7 an acre, are paid for by the sale of bonds, a portion of which become due each year for 20 years, are paid by a tax on the lands benefitted and are a first lien against such lands. The secretary of the districts keeps books that show how much drainage tax remains to be paid on each parcel. On many of these lands the farmers themselves must put in supplementary drains before crops are safe.

Some of the districts are facing a critical financial situation. Some day, the refunding bonds that have been issued to pay the original indebtedness and the new bonds that have been sold to pay for supplementary construction, will have to be paid.

Most of these lands have peat soil with sandy sub-soils. They are interspersed with sandy islands. Many early settlers failed chiefly because the drainage was not complete. Others who were able to endure the hardships of pioneer days have made their farms support their families.

Prospective settlers do well to study the experience of those who have been through the mill, and are establishing a sound agricultural policy for farming these lands. The successful solution to the problems involved means much to the prosperity of the state in general and these counties in particular.

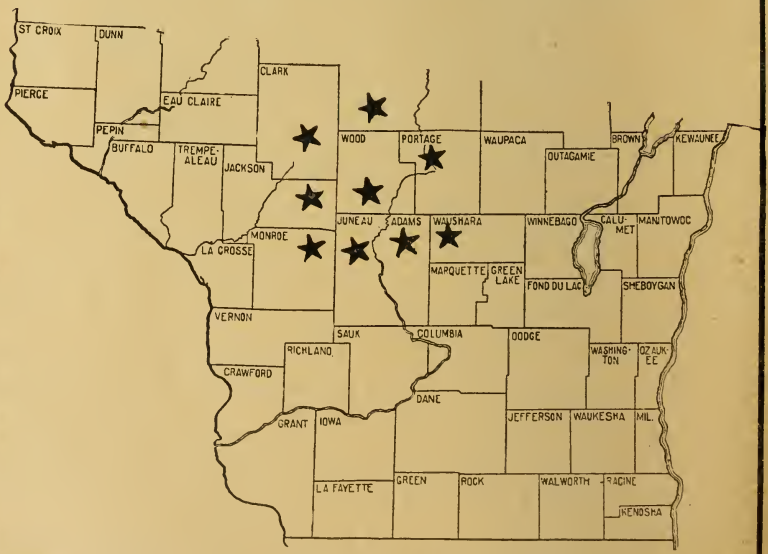


FIG. 2.—CENTRAL WISCONSIN COUNTIES.
The marshes served by drainage districts lie in the heart of the state.

make unnecessary mistakes either in the selection of land or in its management.

The conclusions of the authors are enclosed in panels in the remainder of this publication.

Of the 87 farmers who were at home for interviews, not all had tried to raise all of the following crops but 58 reported having raised profitable crops of oats on the marsh; corn for grain or silo, 52; potatoes, 37; buckwheat, 33; timothy, 29; rye, 29; soybeans, 15; millet, 10; alsike clover, 7; marsh hay, 5; garden truck for market, 5; sugar beets, 4; cabbage, 3; melons, 3; barley, 3; wheat, 2; onions, 2; red top, 1; "million dollar grass," 1; rape, 1; rutabagas, 1; flax, 1.

TABLE 1.—WHO, WHERE AND HOW

Own or rent	Acres	Too wet	Tile used	Depth peat	Sub-soil	Too dry	Years there	Roller used	Fer-tilizer	Early as upland	Colder than upland
Own	930	Yes	No	1′-3′	S-C	No	3	Yes	C-M	Yes	Yes
Own	260	Yes	No	½′-2′	Sand	No	4	No	M	No	Yes
Own	80	Yes	No	3′	Sand	No	5	No	M	Near Ditch	Yes
Rent	240										
Rent	480	Yes	No	5′-6′	Sand	No	2	Should	M	Yes	Yes
Own	220	Yes	No	2′-4′	Sand	No	4	.....	M	.....	.....
Own	190	No	No	2′-4′	Sand	No	22	No	M	.....	.....
Own	200	Yes	No	1′-3′	Sand	No	6	Yes	M	Yes	Yes
Own	400	No	No	2′-4′	Sand	No	6	Yes	M	Yes	.....
Own	200	Yes	No	2′-3½′	Sand	No	4	Yes	M	Nearly	Yes
Own	210	Yes	No	3′	Sand	No	7	No	M	No	Yes
Own	160	Yes	No	2′-3′	Sand	No	12	Yes	M	No	Yes
Own	80	No	No	1′-3′	Sand	No	2	No	None	No	Yes
Own	260	No	No	1′-3′	Sand	No	17	Yes	C	Yes	.....
Own	40	No	No	1½′	Sand	No	20	No	C	Yes	Yes
Own	30	No	No	2′-9′	Sandy Silt	No	14	Yes	M	Yes	Yes
Own	20	Yes	No	2′-6′	Clay	.....	....	.....	.....	.....	.....
Own	1500	Yes	Yes	2′-4′	S-C	No	11	Yes	None	Yes	Yes
Rent	640	Yes	No	16″-3′	Clay	No	4	No	No	No	Yes
Own	223	Yes	Yes	1′-1½′	S-C	No	15	Yes	No	Yes	Yes
Own		Yes	No	1′-2′	Clay	No	.....	No	No	.....	.....
Own	100	Yes	No	4′	S-C	No	15	Yes	No	Yes	Yes
Own	60	No	No	2′	Sand	No	15	Yes	M	Yes	Yes
Own	67	Yes	No	6′	Clay	No	2	No	No	No	Yes
Own	48	Yes	No	5′-6′	Sand	No	30	No	No	No	Yes
Own	20	No	No	5′-6′	Sand	No	9	Yes	No	Yes	Yes
Own	40	No	No	6′-15′	S-C	No	1	Yes	M	Yes	Yes
Own	40	Yes	No	1′-6′	Sand	No	5	No	M	Yes	Yes
Own	100	Yes	No	1′-5′	Clay	No	....	.....	.....	.....	.....
Rent	220	Yes	Yes	4″-1′	Sand	No	6	Yes	M	No	Yes
Own	80	Yes	No	2″-3″	Sand	No	4	No	M	No	Yes
Own	1500	No	Yes	8″-10″	S-C	No	....	Yes	M	Yes	Yes
Own	300	Yes	No	5′	Sand	No	2	Yes	No	No	Yes
Own	200	Yes	No	6″	Sand	No	1	No	M	No	Yes
Own	60	No	No	6″	Sand	No	12	No	M	No	Yes
Own	40	No	No	1′-1½′	Clay	No	6	No	M	No	Yes
Own	80	Yes	No	1½′	Sand	No	30	No	No	No	Yes
Own	40	No	No	None	C-S	No	....	No	No	Yes	No
Rent	300	No	No	3½′-4′	Sand	No	2	Yes	M	No	Yes
Rent	200	Yes	No	2′-5′	S-C	No	2	No	M	No	Yes
Own and rent	1320	Yes	No	4″-18″	C-S	No	4	Yes	M	Yes	Yes
Own	800	Yes	Yes	6″	S-C	No	19	Yes	Lime	Yes	Yes
Own	50	Yes	No	0′-1′	Sand	No	4	No	M	No	Yes
Own	100	Yes	Yes	1′-2′	Sand	No	1	No	M	Yes	.....
Rent	30	Yes	No	1′-2′	Sand	No	1	No	M	No	Yes
Own	1	No	No	2′	Clay	No	4	No	M	Yes	Yes
Own	40	No	No	6″-4′	C-S	No	2	No	No	No	Yes
Rent	400	Yes	No	3′	Clay	No	3	.....	.....	Yes	Yes
Own	145	Yes	No	.....	S-C	.....	7	Yes	M	No	Yes
Own	160	.....	No	0′-3′	Sand	.....	1	.....	.....	.....	.....
Own	160	.....	No	.....	.....	.....	....	.....	.....	.....	.....
Own	1000	.....	.....	.....	.....	.....	....	.....	.....	.....	.....

No.	Own or rent	Acres	Too wet	Tile used	Depth peat	Sub-soil	Too dry	Years there	Roller used	Fer-tilizer	Early as upland
52	Own	10	No	No	3′	Clay	No	8	No	M	No
53	Own	160	Yes	No	2½′	S-C	.....	1	No	M	No
54	Own	55	No	No	2′	Sand	No	7	No	.....	No
55	Own	200	Yes	Yes	12″	S-C	No	12	.....	M	Yes
56	Own	160	Yes	No	12″	S-C	No	5	No	M	No
57	Own	60	Yes	No	.....	Silt Loam	No	....	No	M	No
58	Rent	140	Yes	Yes	6″	Clay	No	7	No	M	Yes
59	Own	100	Yes	No	1′-3′	S-C	No	....	Yes	M	No
60	Rent	640	No	No	1′-2′	Sand	No	4	.....	M	.....
61	Rent	180	No	Yes	4′	Sand	No	2	No	M	No
62	Rent	450	No	Yes	4′	Sand	No	3	Yes	M-C	No
63	Rent	440	No	No	5′	Sand	Yes	1	Yes	M	No
64	Rent	160	No	Yes	8′	Sand	Yes	1	Yes	C-M	Yes
65	Own	160	No	Yes	2½′	Sand	No	1	No	M	Yes
66	Rent	600	No	No	4′	Sand	No	2	No	M	No
67	Own	160	No	No	4′	S-C	No	10	Yes	C-M	Yes
68	Rent	640	No	No	3′	Sand	Yes	4	Yes	M	No
69	Rent	180	No	No	1′-3′	Sand	No	¼	No	.....	.....
70	Rent	140	No	No	1′-3′	Sand	.....	....	No	.....	.....
71	Own	400	No	No	4′	Sand	No	12	Yes	C	No
72	Own	480	No	No	3′	Sand	.....	4	Yes	C-M	No
73	Own	100	Yes	No	4′	Sand	No	14	Yes	M	Yes
74	Land Company										
75	Own	320	No	.....	1′-3′	Sand	.....	1	.....	.....	.....
76	Rent	425	No	No	3′	Sand	No	2	No	M	No
77	Rent	160	No	No	2′-4′	Sand	No	8	Yes	M	No
78	Own	80	Yes	No	0′-2′	S-C	No	2	.....	M	.....
79	Own	279	No	No	0′-3′	Sand	Yes	8	Yes	M-C	.....
80	Own	160	No	No	½ sand 0′-3′	Sand	No	2	No	M	.....
81	Sold	360	No	No	1′-3′	Sand	No	8	Yes	M	Yes
82	Own	160	Yes	No	1′-3′	Sand	No	4	No	M	No
83	Own	160	Yes	No	1′-3′	Sand	No	4	No	M	No
84	Own	600	No	No	0′-2′	Sand	No	15	No	M	Yes
85	Own	320	No	Yes	0′-2′	Sand	No	25	Yes	M	Yes
86	Own	270	Yes	No	1′-2′	Sand	No	12	Yes	M	No
87	Own	80	No	No	1′-2′	Sand	No	4	.....	M	.....

Under "sub-soil"
C = Clay
S = Sand

Under "Fertilizer"
C = Commerical fe
M = Manure

Leading Toward the Light

The establishment of a sound agricultural policy in the drainage districts of central Wisconsin is due largely to the tireless efforts of H. W. Ulsperger, Soils Department, College of Agriculture. At Farmers' Institutes, plat demonstrations and personal visits to marsh farms he has advocated the dairy cow, the silo, soybeans and tame hay with a limited area of truck crops. As the marsh farms develop and become prosperous, they increase the wealth of the counties in which they are located, and build a lasting monument to Mr. Ulsperger's constructive work.

J. G. F. Has 160 acres half sand and half muck or peat and lived there 13 years. The first year he started clearing land on a single forty with a log house on it. Spent two years in clearing these forty acres.

Selecting the Land

Ordinary judgment and observation will tell the prospective settler that there must be good reason why he can buy some of the drained marsh land for $15 an acre. He must be willing to sacrifice personal convenience for a time and put in considerable money and labor to bring his farm up to a point where it will support him and his family.

Newcomers are advised to talk with successful farmers in the locality or even to rent a partially improved farm for a year or two before purchasing land. These precautions enable a better selection of land. With wider acquaintance the settler may be able to find an 80-acre tract in the community that can be picked up for $15 an acre or purchased on tax title or at a foreclosure sale when an agent might charge him a very much higher price per acre for similar land.

Get a financial statement of the district from the secretary. When the drainage bonds have to be paid, the delinquent lands may be sold to satisfy the bond holders and the lands which have paid their drainage tax in full may be called upon to make up the deficiency.

In any event see the *land* twice before contracting to buy, in the spring when drainage may be poor, and then during the summer when the crops on adjacent lands may be observed. See that the top of the water in the ditch during a wet spring is 5 feet or more below the top of the ground, and that all of the land slopes toward the ditch and none of it is more than half a mile from the ditch. There is almost sure to be some land on an 80 adjacent to a ditch that has sufficient drainage, and the rest can be tiled when you are ready for it.

First began tiling ten years ago. Now has 1,200 feet of four-inch tile. Says a settler on raw peat does not get anything the first few years,

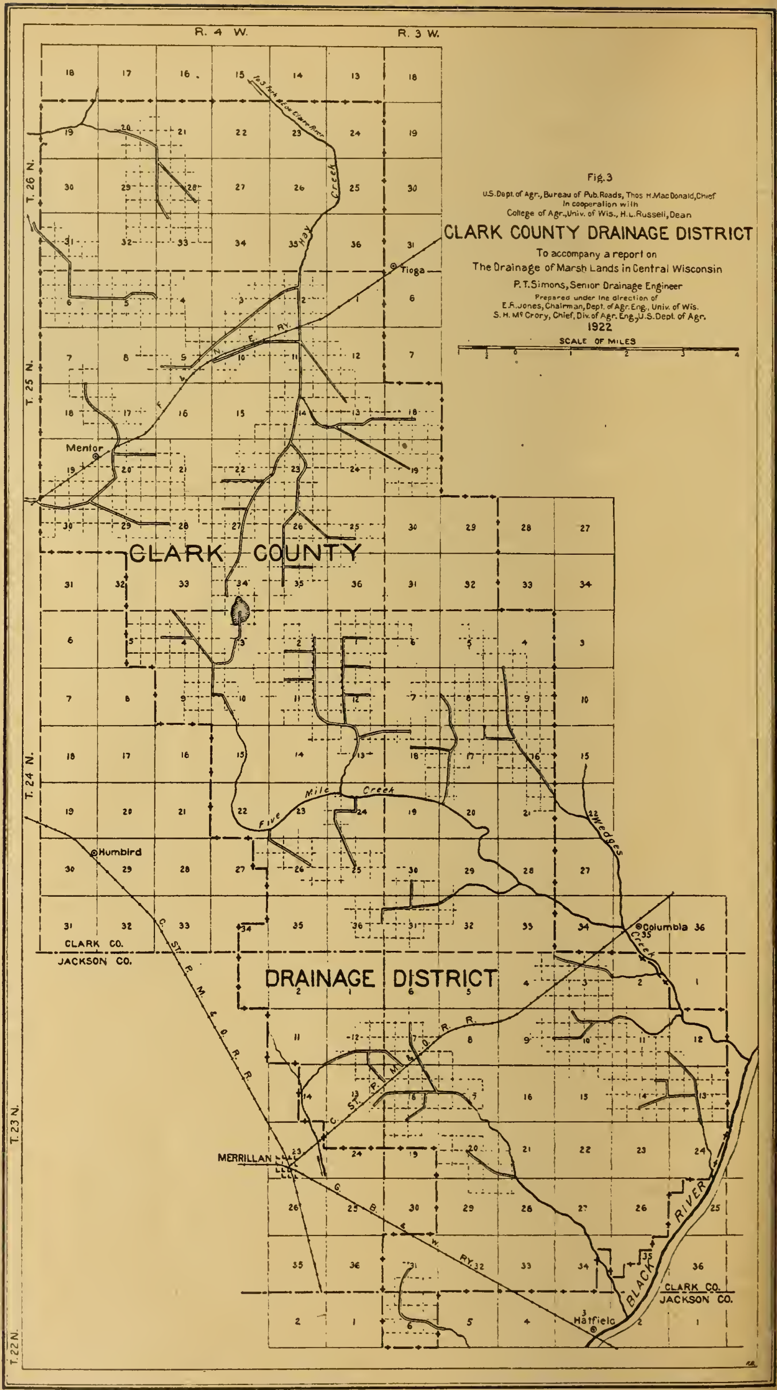
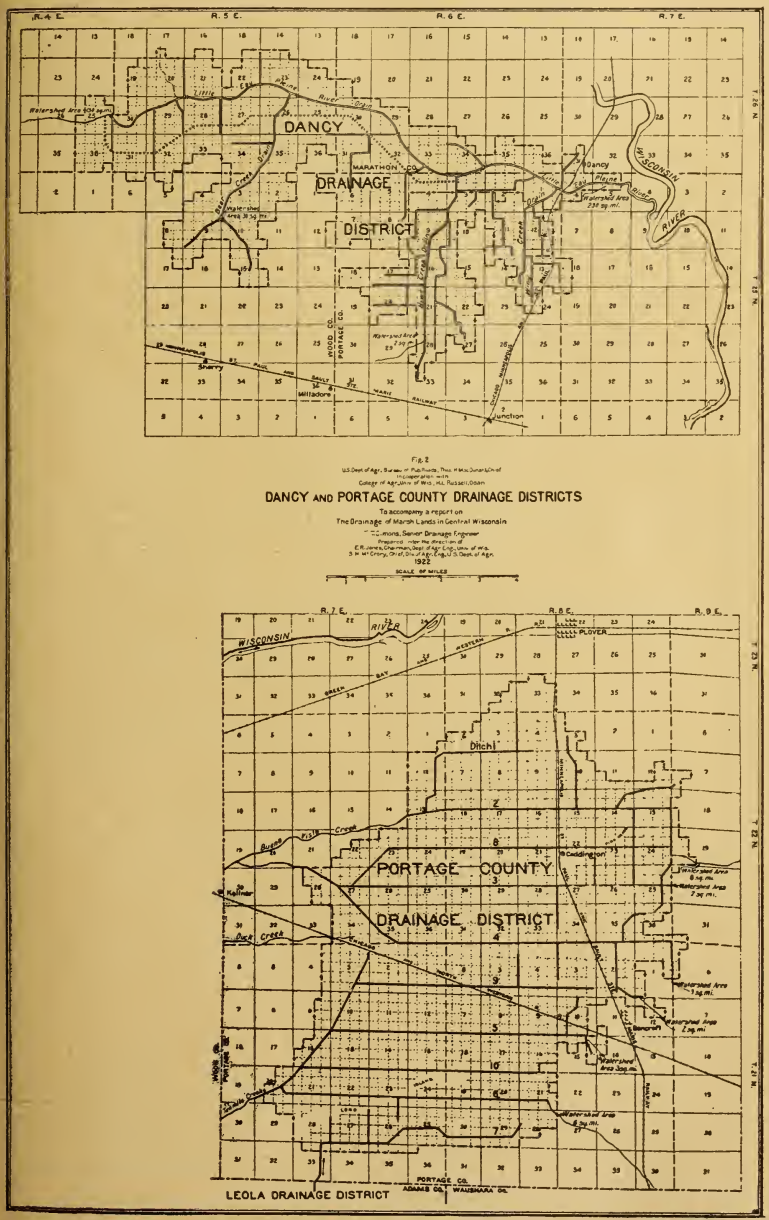


FIG. 3.—IS YOUR LAND NEAR A DITCH?

Study the location and depth of ditches. The ditches are shown with double lines. The roads usually on section lines are not shown.

unless cattle have tramped over it first. Got 360 bushels from 7 acres of oats on the low land. The new settler coming in should have money to carry him through the first few years. Would not under any cir-



DANCY AND PORTAGE COUNTY DRAINAGE DISTRICTS

To accompany a report on
The Drainage of Marsh Lands in Central Wisconsin

1922

SCALE OF MILES

FIG. 4.—FIND YOUR FORTY

Is it where it can be drained? Most of the drains are numbered on the map.

cumstances try to farm land that was all peat. Some high land, probably 50 per cent necessary.

J. M. Has 11 forties. Came in the spring of 1915. Traded city property. All of the present buildings were on the place when he located. The first year he broke up 25 acres. He could not get on the land because the drainage was too poor. Fifteen cows came with the place and four horses. He bought the feed for the stock the first summer. Two and one-half tons of timothy and alsike clover cost $26 a ton. He bought no commercial fertilizer but used stable manure.

1918. Broke up 50 acres. Had 100 acres of buckwheat, loss about 10% from frost; 50 acres of oats, made about 20 bushels per acre; 25 acres of corn filled the silo.

1919. Broke up 50 acres. 100 acres of buckwheat; 25 acres of oats which made 40 bushels to the acre; 50 acres of meadow which had run out. Garden every year.

1920. 50 acres of oats yielded 1,200 bushels; 100 acres of buckwheat made 2000 bushels; 25 acres of corn and 35 acres of millet were fair.

1921. 150 acres of buckwheat; injured by frost and blight made only about 10 bushels to the acre. Corn was good, 60 acres of oats, poor crop. Also put in millet but the seeding failed to catch. Did not have the money to buy commercial fertilizer. Does not need tile, never bothered with water on this place. Uses a roller with good results. Peat is 1½ to 4 feet in depth with a sand subsoil. Drainage tax last year was $577.00. Bothered some with fire in the peat last year. Put in buckwheat because it was easy to put in. Making enough to pay his interest, taxes and living. Local banker said this man refused $26,000 for the farm in 1919. Has kept the buildings well painted. Cultivating the peat makes it decay. Takes two years. Has 40 acres of high land. Hires most of his help. Pays out about $1,000 a year. Keeps 20 head of cows. Buildings worth about $4,000.

H. H. S. Has 280 acres of which 200 is muck. Neighbors have some peat. Paid $30.00 an acre and came from Western Iowa in 1915. Drove around for 5 days before he bought.

1915. Put up buildings with cash on hand.

1916 Fencing, brushing and breaking. Grew a little oats, corn and potatoes. Frost injured corn and potatoes.

1917. Oats, corn, potatoes and buckwheat. No frost that year. Picked many wild raspberries.

1918. Oats 25 acres; corn for fodder; some buckwheat.

1919. Oats, rye, buckwheat, corn and potatoes. Brushed poplar land.

1920. Had 10 or 11 cows. Raised timothy hay, Golden Glow corn and 2,000 bushels of oats. Sold 1,000 bushels.

1921. Oats, poor, 90 acres. Rye, fair, 40 acres. "The marsh is no good for rye. Kernels shrink, but have good milling properties. Buck-

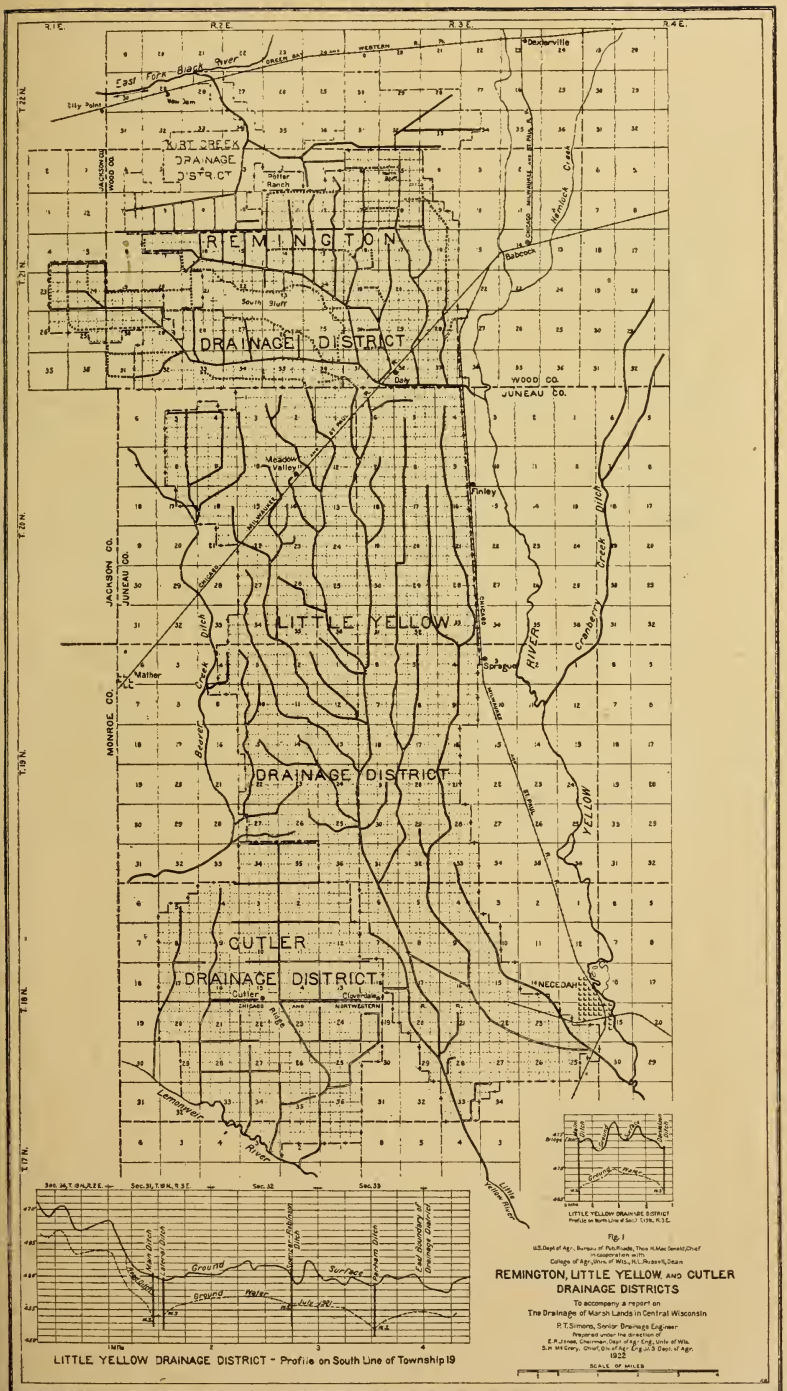


FIG. 5.—BIG BUT UNDEVELOPED
Its lands lie in several drainage basins.

FIG. 6.—LOOK OUT FOR POOR DRAINAGE

Water so near the surface as this makes poor roads and poor crops.

Is It Peat, Muck or Marsh-Border Soil?

Peat is partly decomposed vegetable matter that has accumulated in the marshes. Before drainage it was virtually pickled. After drainage the acids leach out; and air and bacteria come in and it decomposes into muck becoming more solid and darker in color. A technical definition of muck requires that it contain 50 per cent or more of mineral matter, but this is not muck as understood by the farmer. To him muck is a soil which once was peat, but which has decayed until it has lost its tough, fibrous structure. This change usually occurs within three years after drainage and cultivation. In this bulletin the term peat is used by the authors where some farmers, perhaps properly, would say muck.

The marsh-border soils, as the name implies, lie between the marsh and the upland, and in sandy regions are more valuable than either muck or peat.

wheat averages 10 to 15 bushels, one year with another. Use a heavy roller. It takes two years to subdue marsh lands after first breaking.

"Am well satisfied. Drainage tax is $1.00 an acre a year. Debt was $7,700, but have reduced it to $5,700. My 14 cows made me $1,400 last year."

C. M. C. Renting a 970 acre farm. About half muck. Working about half of it.

FIG. 7.—MELLOWED BY DRAINAGE AND CULTIVATION

After the first breaking, marsh soils become mellow and easily cultivated. Some kind of a packer is necessary to make them more compact.

1918. Ninety acres of buckwheat. Sold 1,600 bushels and kept 100 bushels for seed. Good garden. Good melons on the muck.

1919. Six acres corn, some soybeans; good oats, 25 acres. Rye, 24 acres went 12 bushels per acre. Buckwheat, 100 acres; sold 1,200 bushels and kept 150 bushels for seed. Cabbage, 10 acres; sold 18 tons; late planting not good. Leafhopper hurt the potatoes. Good crop of medium red clover on 20 acres.

1920. Hay good except a few spots. 5 acres of soybeans drowned out, but other 15 acres yielded 200 bushels. Corn, 10 acres; too wet in spring and frost in summer. Oats, 37 acres, 600 bushels. Rye 22 acres, 10 bushels an acre. Buckwheat, 60 acres, frost got some of it, saved 100 bushel for seed and sold 600 bushels. "The frost got 30 acres of it and on that piece I got hardly anything out of it. Cabbage 50 or 60 acres. Used a carload of pulverized sheep manure. Thirty acres failed. It grew well until it got to a certain stage. Early frost in July, another

in August; combination of late planting and frost after frost turned cabbage red. Frost also hurt the early planted cabbage. Shipped twelve cars. Twelve ton to the acre. Had 30 acres of sugar beets, planted twice, no good. Tried deep and shallow planting but there was no difference in results."

1921. Soybeans averaged 23 bushels an acre, got 350 bushels from 15 acres. Had 50 acres in corn. Seven acres filled the silo 12 x 30, one twelve acre field made 100 baskets an acre and part of the balance made 15 bushels an acre. "We used 2 carloads of lime on 90 acres. Results noticeable. We seeded 150 acres and got 120 acres. From the 120 acres we threshed 3,500 bushels oats. We had timothy hay which made about three fourths of a ton to the acre. Fifty acres of buckwheat but the wind shelled it out badly. It went about 8 bushels. Seventy acres of rye. Twenty acres of rye winter killed and from the balance we got about 1,000 bushels. We put in four acres of cabbage but the sun was too hot, partly died."

Advantages of Marsh Lands

Wisconsin's marsh lands share her fortunate geographic location. They are near the large markets. They are comparatively level, not subject to erosion, and where the surrounding upland is clay or silt they may receive valuable sediment therefrom. If properly drained they can be cultivated earlier in the spring than can heavy clay. They are free from stone and many of them are free from stumps and brush. They are rich in nitrogen and contain fair amounts of available phosphorus and potash where conditions permit the decomposition of the peat into available plant food. Otherwise in the raw condition the lands are deficient in phosphorus and potash. Sooner or later the use of fertilizers containing these elements is necessary. (See Bulletin 309 Wisconsin Experiment Station.) In the ten years of drainage that some of these lands have had, their acid condition has been materially reduced through ventilation, leaching and decomposition. The bacteria contained in barn-yard manure spread upon the land hasten the process.

G. A. M. Farmed 160 acres for six years. Mostly peat with three feet the greatest depth. No road at first. Came from manufacturing city in Iowa.

1914. Arrived in March. Broke 50 acres. Oats, 10 acres; corn 21 acres; buckwheat, 8 acres; potatoes 5 acres; onions 2 acres. Ditches had not been deepened then. Oats drowned out. Corn made about 30 bushels per acre. Frost killed the buckwheat. Potatoes, fair. Onions 600 bushels. Fed wild marsh hay. Seeded down 10 acres.

1915. Broke 15 acres more. Corn, 20 acres, frosted. Oats, 30 acres, good. Buckwheat 20 acres, frosted. Small patch of potatoes, good. Tame hay, 15 tons from 10 acres.

1916. Broke up 20 acres more of new land. 30 acres of oats made about 40 bushels to the acre. 20 acres of buckwheat was a failure. 20 acres of corn on the high land got ripe. 10 acres of hay, about 12 tons.

FIG. 8.—WATER STOPS THE FIRE

The drainage ditches with water flowing in them are barriers against fires. Where the fire threatens damage before it reaches a ditch, pumping has been successful. Each drainage district containing peat should have a pumping outfit available for such an emergency.

1917. Broke up 25 acres more. Built a silo. 20 acres corn all in silo. Corn on the marsh very late in getting started. 40 acres oats, 30 bushels to the acre, 12 acres of buckwheat blighted not worth cutting. 4 acres of flax, not all got ripe. 13 acres of clover was good. Raised enough potatoes for the house. Had 5 acres of cabbage, good yield.

1918. Corn 25 acres, all but five in silo last of August. Oats, 60 acres, 35 bushels per acre. Rye, 40 acres, winter killed. Eight acres out of twelve of clover winter killed.

1919. Corn 25 acres, got ripe, filled silo. Had 6 acres of corn for grain. Oats, 90 acres, 35 bushels an acre. Flax, 10 acres, total crop 79 bushels. Millet, 6 acres cut for seed, made 50 bushels an acre, sold for $1.50 a bushel locally, Siberian variety.

1920. Corn 25 acres. Froze the last day of July. Oats, 50 acres, 35 bushels to the acre. Rye, 18 acres, five bushels an acre, spring rye

on burned peat. No buckwheat, no onions, no cabbage. Wild hay. Last three years our cattle have not had any hay but we fed the oat straw.

1921. Burned peat not much good for crops first year after it burns. Timothy does well but it is very dusty to handle. Corn 20 acres filled the silo. The balance made about 25 bushels to the acre. Oats, 60 acres, 10 bushels an acre. Soybeans, 32 acres, cut part for hay. Got 220 bushels of soybeans from 23 acres. Carrots did well. Cows have done well since 1917.

Disadvantages and Problems

The five "F's" that may help spell either failure or fortune are: Floods, frosts, fire, fertilizer and finance. Floods are handled by better drainage. The upper limit of the portion of the ground wholly saturated with water should be at least three feet below the surface of the land generally and more than that in the deeper peats. The frost hazard is reduced by better drainage and by having the more hardy crops in the rotation, roots, hay, cabbage and grains. If crops are well fertilized the frost hazard is further lessened. Fires have burned deep holes in dry peat marshes, but seldom where care has been taken to keep the surface free from dry grass or where the peat was well decomposed and compacted. Dry surface material burns well in the spring while the peat is still wet. A deep furrow plowed around the land lessens the fire hazard. The fertilizer problem is simplified by the use of stable manure which, by hastening the decay or rotting of the peat, makes more available the store of plant food in the soil and gives results far in excess of the actual plant food added by the manure itself.

"Early oats do best on the marsh. Settler should put in a small patch of buckwheat for chicken feed. Grow carrots as well as rutabagas because horses like them better. Pumpkins do well and are good for hogs.

"I have 15 cows and 7 spring calves and a pure bred Guernsey bull. Wife takes care of a big flock of chickens. Chiefly Rhode Island Reds. We put up sweet corn by packing in stone jars, alternate layers of salt and corn.

"I sell a few hogs each year. Feed them milk, oats, corn, millet and soybeans, and make them weigh 350 pounds. At first they do not like soybeans.

"I came here three years too soon. Drainage was poor for the first three years. Then the ditches were deepened."

F. W. Has 278 acres, about half peat from 2 to 3 feet deep. Came from Iowa in spring of 1913.

1913. Built small house. Broke 75 acres for oats and corn. Oats made 40 bushels an acre. Corn frosted. Good garden. Three horses and two cows. Fed marsh hay. Broke 75 acres more in the fall.

FIG. 9.—A GOOD HOUSE FOR A STARTER

Prepared roofing for roof and sides outside of sheathing. Wall board on inside of studing.

1914. 30 acres of corn ripened. Minnesota No. 13. 50 acres of oats, light. 50 acres of buckwheat, 20 bushels an acre. 2 acres of flax, too wet. Hay seeded from oats the first year. Shipped in cattle in May, 60 head on range and tame feed. Gained about 400 pounds. Made $300 on the venture and kept four head.

1915. 30 acres of corn, frosted. 50 acres of oats, 65 bushels an acre. 2 acres of onions, 900 bushels from one, 600 bushels from the other acre. Shipped to a company at Wausau, Wisconsin, at $1.00 a bushel to us. Used 300 pounds commercial fertilizer an acre on onions. Had 50 acres of tame hay.

1916. Oats, 40 acres made 45 bushels to the acre. Buckwheat 40 acres, froze except small amount. Corn, 30 acres, frosted August 17th. Good crop of onions, but price was low.

1917. Broke up some more land. Oats 75 acres, made 40 bushels. Buckwheat 25 acres, frost. Corn, 30 acres, got ripe. Rye, 20 acres made 20 bushels per acre. Hay, timothy and clover. Clover getting poorer for some reason. We have dairy cows, 18 milking Durhams.

1918. Rye 100 acres, 18 bushels per acre. Oats 200 acres, 40 bushels an acre part on rented land. Buckwheat, 150 acres, 20 bushels, per acre. Corn, 50 acres, made 50 bushels. Hay, about ton to the acre. Our cows did pretty well that year.

1919. Oats 100 acres made 35 or 40 bushels an acre. Buckwheat 100 acres, froze in spots, about 20 bushels an acre. Rye, 50 acres, made 12 or 15 bushels to the acre. Corn, 35 acres, lost 24 acres through frost. The rest fair.

1920. 100 acres oats, made 45 bushels an acre. 60 acres of buckwheat, made 18 bushels an acre, 80 acres of corn ripened. Made about 50 bushels per acre. 40 acres of tame hay, about a ton to the acre. We had 9 or 10 cows that year.

Choosing a Building Site

Even with good drainage for a building site, a flat low area is less desirable than an elevation because the barnyard is apt to be flooded in the spring, the cellar may have water in it, and the view is less atractive than it is from an eminence. Fortunately, almost every forty in the drainage districts of central Wisconsin has "islands" of hard land rising from 5 to 10 feet above the marsh. Where these islands are on the front of the forty, near the road, and contain two or three acres or more, they make excellent building sites. The sandy soils of these islands also enable the farmer to raise a greater variety of special crops. Watermelons, for example, thrive better on sandy land than on muck. The marsh border land makes a good garden.

1921. 75 acres of oats, made 22 bushels an acre. 75 acres buckwheat, 12 bushels an acre. 40 acres of corn ripened, about 100 baskets to the acre. "Commercial fertilizer almost doubled the yield. We can't raise barley without fertilizer. Roots, dairy and truck crops are best. We can raise the best of feed here. One-half acre of onions this year made 300 bushels and sold for $2.00 per bushel."

W. C. Has 160 acres about half sandy upland and half marsh. Came from Rock Island where they were engaged in supplying milk for the city and were experienced in raising poultry. Located in the spring of 1919. Brought 8 horses, but 4 were plenty. Broke and cleared the first year 33 acres. 10 acres are open marsh and on the whole place we have about half upland and marsh. The first year raised 566 bushel

of oats from 20 acres of new breaking; 68 bushels of buckwheat from 7 acres of mixed soil; 4 acres of spring rye made about 11 bushels an acre. Started with 11 cows and patches of corn here and there and everywhere we could find an open place. Built a silo the first year and filled it about two-thirds full.

1920. Raised 700 chickens. Raised feed enough for the cows. (Note: These people have a good start. The wife is a very energetic person. Have good small barn with modern fixtures inside including a cement floor.

H. C. Y. "Bought 9 forties in 1913. There is a ditch running south through the center of land. Also lateral ditch. The land was peat, broke about 15 acres in 1913."

FIG. 10.—BARN FOR A BEGINNER

A cheap and warm barn made from marsh grass and poles. Let the cows pay for a better one later.

In 1914, 40 acres of corn, got ripe. Good garden.

In 1915 broke 40 acres more. 10 acres of oats. Usually raised 40 acres of corn. Frost got it twice. Built a silo in 1915. "Buckwheat makes 20 to 25 bushels an acre on new breaking. The greatest difficulty with buckwheat is frost. Raised from 30 to 60 bushels per acre of oats. Onions from 300 to 600 bushels per acre."

"In 1920 I had 60 acres of oats, 40 of corn, 40 of buckwheat, putting in soybeans with the corn. We can use soybeans where clover does not do well. Frost may come in August. No tiling needed.

"Sold the place last spring at a fair profit. Wife's health poor. I was successful after I quit using Iowa methods. If I had it to do over again I would not have bought so much land. That's where nine-

tenths of the fellows fall down in this part of the country. I would have gone more into cows. Tell the new settler to get cows, put up a silo, soybeans with corn, get some lime to get the clover started, and raise chickens. Turkeys are good, too."

Phosphorus, Potash and Peat

While marsh soils are high in nitrogen, they are generally low in phosphorus and potash. Yet in a typical Juneau county marsh the peat averaging two feet deep contains 1,500 pounds of phosphorus and 2,700 pounds of potash per acre, or enough to raise 40 bushels of corn per acre for 50 years. That the 87 farmers interviewed are unlocking this phosphorus and potash by inoculating with manure is proven by their crop yields. Those crops would be better if some commercial fertilizer containing phosphorus and perhaps lime were added, but the yields of field crops are fair without them, where even a small quantity of manure is available for inoculation. Truck crops generally require an extra supply of mineral fertilizer to make them profitable.

J. Q. D. Has 640 acres of which about one-fourth is sandy upland and three-quarters marsh. Has been on the place 21 years. Raises corn, clover, and potatoes on the sand island. On the Wood County soil survey map his land appears to be classed as peat, shallow and deep.

FIG. 11.—HOUSE CONVERTED INTO BARN

When this farmer got ready to build his second house, he moved this one up to the old barn for stable space and feed storage.

1917. Corn, 16 acres. That on the high land got ripe; that on the low land did not ripen. Corn is safe on the marsh for silage. Oats, 40 acres, made 46 bushels per acre. Buckwheat, 20 acres, made 13 bushels per acre. 15 bushels a very good yield for buckwheat. A small amount of rye that made about 11 bushels to the acre. Hay, some alsike, does well on the marsh. Made about 1½ ton per acre. Used a roller and a carload of lime putting it on the oats. There was little if any difference on the land that was limed and that that was not limed.

1918 to 1920. Does not remember details but got fair crops every year unless frosts, wet or dry weather occurred.

Burning Deep Peat

Some of the thin peat soils have been ruined by burning.

Peat 5 or 6 feet deep may have a layer of raw vegetable matter—probably moss—on the surface to a depth of one foot. A good seed-bed is impossible until this raw layer is removed. To burn it during dry weather is dangerous. Break it during the late summer and the dry furrow slices may be burned off safely the next spring while the sub-soil is too wet to burn. Near Valley Junction 40 acres was plowed and burned to an even depth in this way. The seed bed was then prepared by disking. The loose layer on top was burned in this way on the deep peat in the Portage County District also. It left a firm soil with the ashes for fertilizer. On the other hand the fire so kills the soil bacteria that a light application of barnyard manure is necessary to restore their activities in unlocking the plant food in the peat. Furthermore where the peat is less than 3 feet deep we cannot afford to waste organic matter by burning. It all needs to be saved to form plant food as it decomposes.

1921. Corn, 21 acres. Half high land, half low. Oats, 30 acres, made 20 bushels per acre. Buckwheat, 11 acres, 10 bushels per acre. On the corn proposition one year with another high land ripens better. New seeding on the marsh cut about 1½ tons to the acre. New seeding on the upland about one ton.

1922. Has 30 acres plowed for oats on the marsh. Corn to be on the sandy upland. "Develop the country by 160 acre farms, get cows;

tramping of the soil by the cattle helped the land." Used some wild hay and fed grain. Dairy cows are surer than running stockers and feeders. Plant soybeans. Advise the new settler to put his garden on marsh border soil instead of clear peat. Have hens and fence in the garden. "We could pasture my cows all winter on blue grass except for the snow. Increase the size of the dairy herd and the size of the farm together. Sell dairy products not feed. Locate close to the ditch. Not possible to overdrain muck land. We sometimes have frosts in July and August. I would advise commercial fertilizer from what I have seen but barn manure is better. Get some pigs and feed them skimmilk. Prefer shallow peat for then I can mix the sandy subsoil with it and make it more compact. Fire is a handicap on these marsh lands; the first burning is not so bad, but more than that is a handicap. Cultivation of the land helps to stop the fire hazard. The majority of the land in this district is held by outside people. The annual drainage tax is 75c to $1.00 an acre."

FIG. 12.—A SMALL CHEAP GRANARY
Mouse-proof, dry and large enough for a small dairy farm. Used chiefly for soybeans.

A. C. B. Has 165 acres, half upland, half marsh of the marsh border type. Located in 1898. It was dry then. He raised crops for three years and then there was failure because the land was too wet. The peat has burned off leaving muck. Some white pine timber on upland.

Had had considerable experience with bees. Now has 43 colonies in the cellar (winter). "The first bloom of the blueberry and huckleberry is followed by blackberries, goldenrod, spanish needles and buckwheat blossoms, but these buckwheat blossoms do not always contain nectar." Keeps hybrid Italians. "A colony will make 75 pounds of honey one year with another.

FIG. 13.—THE SMALL SILO HELPS.
A silo pays where there are five cows and the accompanying livestock.

There are flowers in the spring and fall both, always something for bees to work on. Bees are not profitable if put in a locality where the land has not been improved.

"For the new settler recommend part high land and part marsh. When you break new tough marsh you can't plow it the next year, but it should be disked, sowed to oats and seeded down. Recommend potatoes, corn and rye and insist that the settler go into the dairy business. Beef no good. Do not put your garden on peat but put it halfway between, on marsh border. The land may be too wet half a mile away from the ditches. Buckwheat yields from 6 to 30 bushels. Frost has not injured the corn during the last three years. Frost sometimes injures crops in July and August. Can raise good potatoes, on the new marsh don't do well. Advise the beginner to put potatoes on the upland the first year rather than to put them on the marsh on account of wire worms. We grow better soybeans on the marsh than we do on the sandy upland."

FIG. 14.—MORE SILO FOR MORE COWS

These hoops should be tightened before the silo is filled. Concrete silos are expensive on the marsh because of the scarcity of gravel.

C. S. Has 160 acres. Located 4 years ago. Soil classed as peat. Some sandy upland. Poor drainage. Outlet ditch is too shallow. Did not know it till after he bought.

1918. Broke up 40 acres. Put in 30 acres of buckwheat, frost damage, got 155 bushels. 10 acres of oats, got 175 bushels. Poor garden. Not on the marsh.

1919. 34 acres of buckwheat, yielded 700 bushels. 22 acres of oats, yielded 400 bushels. 1 acre of rutabagas, 600 bushels. 8 acres of rye, 2 bushels per acre. 2 acres of corn, good. Garden poor.

1920. Broke 8 acres of new land. 10 acres of corn, froze in July. 32 acres buckwheat, got 60 to 70 bushels all told. Oats, 20 acres, got 250 bushels. Rutabagas ½ acre, 100 bushels. Had wild hay.

1921. 8 acres of corn, good. 24 acres of buckwheat, got 300 bushels. 9 acres of oats got 234 bushels. Rutabagas poor. Tame hay, 17 acres, fair. Soybeans, good on well-rotted muck. Has 9 cows. Would

put on cows right away from the start instead of depending upon the grain crops. A mortgage of $5,000.

C. O. Has 160 acres two-thirds marsh, balance marsh border. Neighbor of C. S. Likewise deceived on the drainage.

1918. Broke 32 acres, put 10 acres in oats, fair. 20 in buckwheat, got 142 bushels from 30 acres. Potatoes 2 acres on the marsh, 200 bushels.

1919. 10 acres of rye, harvested 18 bushels. Broke up land along the ditch, put in 25 acres of buckwheat, got 25 bushels to the acre. 6 acres of corn, good. Garden good including tomatoes.

Cheap Buildings at First

A 12 x 24 house with 12 foot studding will answer the purpose the first two or three years. Put on a good prepared roofing. Sheet the sides with shiplap. Before winter put roofing on the outside and wallboard on the inside of the first story. The attic can be used for sleeping without this inside protection. When ready to build a better house, this one can be used for a granary, shop or storage.

Cut poles for a barn and use marsh hay for a roof. Let the cows pay for a better barn later; also a better silo to replace the first cheap stave silo. Build the chicken house, machinery shed and hog house of any cheap material available. A root cellar in a sand island costs nothing but the labor. If the tops are not trimmed to close, rutabagas and other roots will keep well. A root cellar also will serve as a place in which to store potatoes and garden vegetables.

1920. 20 acres of oats, got 500 bushels. 17 acres of buckwheat, 185 bushels. 5 acres of corn, poor, but used for fodder. Rutabagas, small patch, did fairly well. Wild hay.

1921. 22 acres of oats, 10 bushels to the acre. 17 acres of buckwheat, 168 bushels. 15 acres of corn filled silo. Rutabagas, too dry. Potatoes, half an acre, 30 bushels. Have 9 cows, plenty of feed for them. Land has poor drainage, two-thirds of it too wet.

J. M. Rents 600 acres. Fire is a serious hazard. Hauled sand three weeks to save 14 acres of clover. Peat fire worse than upland fire because you can see where the upland fire is going while the peat fire goes under.

FIG. 15.—MORE POLES AND MARSH GRASS

Poles make a good crib.

F. W. "As the land is drained the yield of oats decreases and the quality becomes better. There is serious leaching of fertility. When they put in the ditch we got 76 bushels to the acre the year afterward. Since that time, however, our yields are decreasing but the quality is better. The straw is short now and I believe that unless we can find some way to get the water table higher we can't do much. There's all that water going away in the ditch. I believe we should control it by dams and sub-irrigate the land. Then there is this fire proposition, pretty serious too. When I took my children to school I had to drive through some awful smoke and once this summer if the wind had turned our

Easy Plowing First

Limit the first year's operations to farming the most convenient and surest portions of the newly drained land. A ten-acre tract free from brush, with drainage assured by being next to a deep ditch, easy to break and accessible makes a good field. The next year enlarge this field by bringing in some of the land the breaking of which may be attended with greater difficulties. In the meantime pasture these wilder or wetter portions. It will help to subdue them. Even men with plenty of capital make mistakes if they start farming new land on too large a scale.

way, we would have got it. The whole neighborhood was out fighting fire. I believe the fertility of our land leaches through into the sand the way our drainage stands to-day."

W. B. ..Has 600 acres. Largely sand but some marsh. Silo blew down, did not put it up. "Found it unprofitable to feed the stock anyway because we did not have any milk house. Seven cows, not doing well. In 1920 sold $1,200.00 worth of hogs. This year we had some hogs, did not care much whether we had them or not. They did not do very well because the acorns in the woods were not so good this year. Nobody here likes to milk. Tax last year was $600.00 including a drainage tax. The hens are not laying very well. Have 100. We had some tame hay. Timothy and red top does well on the low land. We have corn fodder in the hay mow and a silo filler. We did not have any garden this year although the marsh is good for garden if the season is not very wet. Can raise as good potatoes on the marsh as on the high land."

FIG. 16.—CORN ON THE DITCH BANK

Good drainage means good crops. Plow near the ditches first where drainage is sure to be good.

I. A. H. Has 270 acres. Forty acres high land, balance marsh. Located October, 1909. Old log house on the place occupied by a trapper, also old barn. Had 25 acres in crops first year on the high land. In 1910 sold $85.00 worth of hay. Hard struggle because of limited capital, but sent children to school. They have now graduated from high school. "Four years ago, 1917, I broke up the first marsh. Drainage poor before that. Six acres of oats, made 46 bushels to the acre.

"In 1918 on the marsh 11 acres of oats, made 40 bushels to the acre. 4 acres potatoes yielded 120 bushels an acre. Corn on the high land, balance of the low land for hay. Four acres of buckwheat, gave

14 or 15 bushels to the acre. Had 22 head of cattle, milking Durhams, home raised. They did well.

"1919. On the marsh 13 acres of oats, made 36 bushels per acre. Four acres of buckwheat, frosted, hauled it in for chicken feed. Four acres of potatoes, good. Have kept from 15 to 23 head of cattle every year.

"1920. Corn on high land and marsh. Ten acres of oats on the marsh, 215 bushels. Two acres of buckwheat good. Four acres of potatoes, 100 to 125 bushels an acre.

"1921. On the marsh, oats 18 acres light. Eight acres corn, 40 bushels an acre. Fifteen acres of rye sowed this fall. Recommend timothy and red top first year on the marsh. The deep peat is not good. It acts too much like a sponge. Hard to drain.

Cows for Milk

A herd of dairy cows is imperative on every successful marsh farm. The farmer unwilling to milk twice a day had better stay away for the monthly cream check is what he must depend on to buy groceries and pay the interest and taxes.

Roots, corn silage, alsike hay, soybean hay and oat hay can be raised on the marsh and are good feeds for cows. Corn ripens for grain about three years out of five. Oats is the best grain to supplement the corn. The silo is profitable for five or more cows with the accompanying young stock.

Start with a small herd. Select the dairy breed that predominates in the community. The county agent will help in finding good cows to purchase for a start. Raise the heifer calves on skimmilk and gradually build up a good herd.

"Would put buckwheat on new land even if I did not get a crop because it helps fit the land for other crops by causing the sod to rot. It is the best and almost only crop we can grow on new breaking. Flax does not prepare the soil in the same way. A small farm with cows is best. The frost is a limiting factor with buckwheat."

A. B. Is farming 320 acres. Located 1896. Began growing crops the first year. Formerly in store business. His land had burned off in 1894.

1895. Oats, 23 acres, 70 bushels an acre. Timothy for hay.

1896. 100 acres oats, good but some drowned out. Twenty acres of barley. Twenty acres of winter rye. Three acres of potatoes. Grasshoppers bothered this year. Millet yield good.

1897. No farming except on the higher pieces of land, too wet.

1898. "From 1898 to 1917 we lost crops more or less every year because of lack of drainage. Some years the frost, another year, too wet. I was not able to farm at a profit until 1917 except to keep some stock to sell in the fall. Grain farming was practically a failure. But I stuck and made a living."

1917. Ditch on each side of land is now 8 feet deep and 24 feet wide at the top. My land was marsh soil, part of it, about 50 per cent,

Breeding for Beef

Seed the land with tame grass and raise beef calves of a beef or dual purpose breed. One farmer (F.A.) near Valley Junction has a herd of high grade Herefords from which he sells a carload of steers a year. He raises corn enough to fatten them, but attributes his success more largely to the excellent Kentucky blue grass pasture on the drained marsh. He broke the marsh, disced it well, and seeded blue grass, timothy and alsike with oats or fall rye for a nurse crop. He harvested the rye but cut the oats for hay and got a good catch of grass in each case. The blue grass stays seeded permanently. This marsh has a ditch on the lower side of it to remove the flood water and a ditch on the upper side of it to cut off the seepage. The ditches are ¾ mile apart and are deep enough to reach into the sandy subsoil. Beef is the cash crop for this farmer, but he has a dairy herd on the farm also. He agrees that the monthly cream check that comes from the dairy herd is indispensable to the marsh farmer.

Beef cattle have been grazed on drained marsh lands with varying degrees of success. Generally where feeders have been purchased in the spring and sold in the fall, the increase in weight scarcely compensates for the decrease in price and there is no profit. There may be a loss in wild pastures where the cattle must walk distances for suitable grass. The tramping is good for the soil but not for the cattle.

two feet deep; about one-tenth sand island. The rest is marsh border land. Rye, 15 bushels an acre. Oats, 40 bushels an acre. Buckwheat, spotted with frost, 10 and 15 bushels. Corn hit by frost. Tame hay yield small.

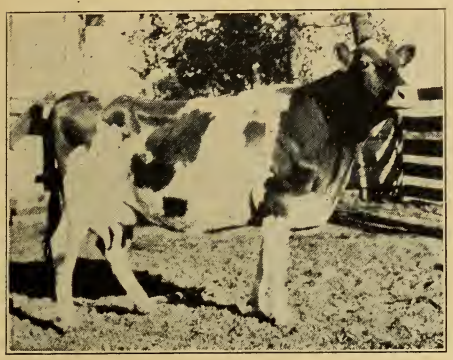


FIG. 17—THE SALVATION OF THE MARSHES

The dairy cow has come to the rescue. Her monthly cream check supports the family and pays interest and taxes and her daily dropping of manure fertilizes the land. She consumes roughage that would be hard to sell for profit.

1918. Corn good. Wheat, 22 bushels per acre. Rye good. Buckwheat, frosted more or less.

1919. Corn, 15 acres; filled silo 12 x 26 with 6 acres. Rye, 15 acres, poor. Oats, 40 acres, 1,600 bushels.

1920. Corn, good, better than 1921. Oats good. Rye winter killed. Threshed in all 350 bushels.

1921. Corn, 30 acres, drilled in for silage. Filled silos. All got ripe. Oats, poor. Rye, 8 acres, did not fill very well. Flax, 8 acres, got 65 bushels. Soybeans 1 acre, Ito San variety, 17 bushels. Eyebrow

FIG. 18.—WHERE CREAM IS MADE INTO BUTTER

The creamery in the Cutler Drainage District. There was neither creamery nor cows before drainage.

variety 1 acre, 16 bushels, Early Black 2 acres, 30 bushels. One third land and balance muck is a good combination.

"Deep peat is too light. Soybeans will grow on more peaty soil than corn. Oats is a good first crop. Buckwheat is too much of a

chance crop. Either heat or cold will hurt it. I should have gone in stronger for potatoes. Grazing stockers and feeders is a gamble. Rutabagas, table beets and poultry are good."

The Cash Crop

Cabbage and onions on well drained muck bordering a deep ditch are successfully grown on the marsh. Stable manure or commercial fertilizers, perhaps both, are necessary for large yields. If the land is poorly drained onions grow mostly to tops. On such land the stand of cabbage is uneven and the plants are weak and unable to withstand cabbage diseases.

These crops are hardly to be depended upon on raw peat. They require a great deal of labor in growing and harvesting. The seed bed must be well worked up and fields kept free from weeds and cultivated. Some Wisconsin cabbage growers plant turnips or radishes in every tenth row to help control the cabbage maggot. It is not safe to grow either onions or cabbage year after year on the same land.

As with all truck crops the price is uncertain and fluctuates greatly. Unless the onion grower has drying and storage facilities he must accept the price offered when the nation's harvest is gathered. There is no way to tell in advance what this price may be. Cabbage is more bulky in proportion to value but is also subject to price fluctuations. As yet there are no large storage warehouses for onions or cabbage in the drainage districts of central Wisconsin. Until such facilities are provided settlers should not undertake to grow these crops on large scale. The matter of organizing communities for growing these crops on a large scale and the construction of suitable warehouses is worthy of consideration.

Marsh farmers are raising potatoes for table use and for the market. Extensive potato growing requires potato raising machinery. Potatoes are easily injured by frost and the market price depends largely on the nation's harvest of this crop. The dairy cow is a surer proposition.

C. C. Has 80 acres and 9 grade Holsteins. Worked in the neighborhood and rented land for four years before purchasing. Half upland and half marsh.

FIG. 19.—HOGS AS A SIDE LINE

Skimmilk and soybeans make good pork.

1919. 19 acres of buckwheat made 20 bushels an acre. Four acres of oats, 150 bushels. Broke 16 acres on his own place and rented 20. Fifteen acres of oats, grew 360 bushels. Corn was poor, seed didn't sprout. Three acres of rye gave a total of 29 bushels, sold in October.

Poultry as a Cash Crop

Raising poultry is second in importance only to milk production in farming these lands. Chickens are good foragers and get much of their feed from waste. They mature quickly. Only a small amount of money is needed to start and the increase is rapid. Select good strong birds as foundation stock, keeping them in clean quarters, free from lice and giving plenty of range and feed. Corn, buckwheat, oats, both dry and sprouted, and skimmilk are good poultry feeds.

1920. Oats, 24 acres, 500 bushels. Buckwheat, 12 acres, frost, drowned out got 45 bushels all told. Corn 7 acres, cut for fodder. Potatoes, frost July 29th killed them. Hay, timothy and clover does not do well unless limed. The high land grows the best garden in my judgment. Gardens poor on peat.

1921. Buckwheat, 15 acres on marsh, got 136 bushels. Oats, 22 acres, threshed 224 bushels, Rye, 4½ acres, got 37 bushels in all. Corn, 8 acres good. Garden good on both the sand and marsh. Have no vegetables for winter.

FIG. 20.—CUCUMBERS FOR GARDEN AND CASH

Best on sandy islands or border marsh because of frost hazard. The salting stations at Necedah and other marsh towns make cucumbers a good cash crop. Learn the cucumber business by starting on a small scale.

Most years he can depend upon rutabagas. Has marsh hay and corn for his cows. Children have helped financially.

J. P. Located on 52 acres 10 years ago old house on the place, unfit to live in at the time. Seven children. Came from Iowa, carpenter, plasterer, laborer. Bought his place for $10.00 an acre. Mostly marsh. Arrived February 28, 1912. bought 2 horses, one for $40.00, "the other for nothing." Fixed up the old house, bought a cow in June for $35.00. First year, twelve acres in crops. Corn ripened, oats too dry, land run out. Cut oats for hay. Potatoes poor. Garden good.

Second year same as first year with buckwheat and oats better. Broke some upland.

Third year, 35 acres in crops; 4 cows; 3 acres potatoes, got medium yield. Rutabagas good. Too much drainage leaches away the manure. Land needs lime and manure. You can't tell the new settlers anything.

In 1922 he put in 25 acres of oats, corn, 25; potatoes 10, soybeans 3, Sudan grass 3. Bought an additional tract of land on the south, about 100 acres. Got it on tax deed. Now has 90 acres ready for cultivation all told. Has comfortable house about 6 rooms; pole barn, pole corn crib and is one of the few settlers seen who provides good shelter for his machinery, all of which was under cover. For six years his children walked four miles to school. For three years they walked three miles and now within two miles of school. He reports some damage to crops from frost.

W. E. S. Has 360 acres. Farmed one year, moved away for two years and then came back. Built a new house, 20 x 24 with 8 foot studding; two small children. Has farmed in Michigan.

Last year rasied 500 barred rocks. Chicks hatched with hens. Sowed oats as green feed for chickens. Ground feed for chicks 3c a pound. A year ago wintered 300 hens and used some sprouted oats. Has good buckwheat field for later summer and fall feed for chickens.

Oats make 15 and 20 bushels per arre. Poor yields of Rosen rye. Has about 10 cows, five heifers, 5 yearlings, all grade Holsteins that have come through the winter in good condition.

Farm machinery, seeder, grain binder, corn binder, mower, out in the snow. Have a hired man. Chickens have tuberculosis.

E. R. Has 80 acres, chiefly marsh border soil. Some sandy upland and some muck, clay beneath the sand.

1920. Oats made 20 bushels per acre; corn 12 bushels. Old hay land badly run out.

Tools and Machinery

A plow of the half-breaker type is commonly used on the marsh. · A heavy disc is not advised by the farmers unless plenty of strong horses or a tractor are available. They prefer a drill instead of a broadcast seeder because the seed must be put in deeper than in upland soils. A hand planter is often used the first year or two in planting corn. A spike tooth harrow with wooden bars is favored because it is lighter. A heavy roller is necessary. Some have made one by filling a 12-inch tube with concrete. They advise buying a mower and hay rake before either a grain or corn binder. A manure spreader on the marsh farm is important because it is hard to spread a light dressing of manure evenly by hand. A wide tired high wagon is preferred. The ordinary walking cultivator is used while fields are still small. Axes, a cross-cut saw, simple carpenter and garden tools find a place on every farm. It is unsafe to depend on borrowed or rented tools or machinery.

1921. Potatoes 4 acres, fair. Oats 20 bushels per acre; buckwheat 22. Frost hurt the corn some but it went 50 bushels per acre. Frost also hurt the oats. Sold about $450 worth of fur, muskrat, mink, skunk, 'coon and weasel. Trapped them along the ditches.

Counting the Cost

In order to point out the more important items several experienced and successful marsh farmers were asked to prepare tables or budgets

showing the expense that should be provided for by a beginner. They are presented here, also remarks of the farmers furnishing the estimate.

In each case it was assumed that the settler buys 80 acres of well-drained land on the long-time payment plan at $15.00 an acre, plus the

Crops Grown on Marsh Soils

Frost Resistant	*Semi-Resistant*	*May Be Injured*
Hay Crops:	Corn and soybeans for silage	Soybeans for seed
Alsike and red clover	Early potatoes	Buckwheat
Timothy	Rape	Flax
Oats and peas	Strawberry	Corn for grain or seed
Blue grass	Celery	Late potatoes
Orchard grass	Soybeans for hay	White beans
Rye grass		
Redtop		
Alfalfa		
Vetch and rye		
Grains:		
Winter wheat		
Winter rye		
Truck Crops:		
Sugar beets		
Mangels and table beets		
Cabbage		
Onions		
Carrots		
Turnips		
Rutabagas		

unpaid portion of the drainage tax, and that he has $1,200 or more with which to start farm operations. It was the opinion of the farmers interviewed that what is given applies equally as well with a man having $10,000, that he should operate on a small scale until he has recognized and solved the special problems confronting him.

Budget I.

House, necessary purchased material 12 x 16	$200.00
Wagon, new	130.00
Team	200.00
4 cows	200.00
2 young pigs	20.00
Yearling steer	25.00
Chickens	15.00
Harness	50.00
Plow	40.00
Disk	45.00
Walking cultivator	10.00
Miscellaneous tools	50.00
Store bill 12 mos. at $15.00 per month	180.00
	$1,165.00

Remarks. "The above budget does not provide for a barn or feed for team until it can be grown and the settler would have to depend on cows to pay interest and taxes. Men sometimes fail because they will not take advice. One new settler lost 70 acres of buckwheat because he waited until it all got ripe. By that time most of it had shelled out. The same man left his potatoes in the ground until it froze up in November. A settler should not work out for wages because it keeps him from developing his farm. Illinois men coming here buy too much land and try grain farming and fail. Too many traders are dealing in marsh land at excessive prices. Commercial fertilizer is a money maker for cabbage, but I believe stable manure is sufficient for good yields of general crops.

FIG. 21.—STOREHOUSES FOR CABBAGE

Successful cabbage marketing requires a store-house from which shipment can be made when the market is right.

"The first year I would recommend that the new settler sow 6 acres of oats for hay, seeded down to alsike, red top and timothy. Sow 6 acres of millet, possibly seeded down if cut before ripe. Buy your millet seed from a seed house. Don't depend on millet seed grown by a farmer around here because as a rule it is not cured well enough to make it safe to sow. Sow about June 1st. Sow 2 acres of barnyard millet to ripen and be fed to chickens without threshing. Sow about 10 acres of oats for grain. Figure on about 20 lbs. of hay for each cow daily and possibly 15 lbs. of roots. Put in 6 acres of Ito San soybeans for hay.

"Break and plant 5 acres to Flint corn for fodder or better still the Corey variety of sweet corn, soiling crop. Have two plantings of corn for fodder, early and late. Fall breaking is best for oats on the marsh. Wild pasture is a disappointment.

"Break up land on both the sandy island and marsh for rutabagas

FIG. 22.—POULTRY FOR MARKET

Poultry requires only a small cash outlay. (Send to the College of Agriculture for bulletins.) Buckwheat, injured by frost and unsalable, makes good feed for poultry.

and turnips. I would suggest a pit in the ground instead of root cellar at the start. My root cellar is about 12 x 40 feet and in it are potatoes, cabbages, parsnips, turnips and rutabagas. Sow turnips during the last cultivation of corn. Five tons of roots for 4 cows for the winter.

"Plant potatoes on both the high and low land, about an acre on each. Potatoes are the best cash crop the first year on a peat marsh. Put your garden chiefly on the marsh.

"The settler should own his own team and and tools. Hiring is not a practical proposition because when the settler wants work done, his neighbor needs the use of his own team and outfit.

"If you have four cows buy two small pigs and possibly a steer calf for meat for winter.

FIG. 23.—THE HEAVIER THE BETTER

This iron drum is filled with concrete to make it heavy. To make it heavier, load the rack with stone. Unrolled, mellow marsh soils may dry out to a depth of three inches. Rolled after seeding, they remain firm enough to support roots and hold water.

"Watch for auction sales to buy tools, harness, horses and cows. Build a pole barn with marsh hay roof. If you buy new tools, of course, it will cost you more than the figures mentioned."

Soybeans for Hay and Seed

No marsh farm can afford to get along without soybeans. The Ito San, Manchu and Black Eyebrow varieties mature in about 115 days. The Wisconsin Early Black matures in 105 days, and to that extent is better adapted to fields subject to frost. They can be cut for hay even when hit by frosts.

Budget II.

Materials for house	$250.00
Wagon, get one second hand, if possible	75.00
Team, chunks	200.00
3 cows and 1 heifer	160.00
2 spring pigs	8.00
Harness	40.00
Plow 14", half breaker type	20.00
Disk, not over 5' wide	40.00
Walking cultivator	5.00
Harrow, 8 feet	12.00
Miscellaneous tools, axes, shovels, hoes, saws, etc	25.00
Chicken house 12 x 12, poles	10.00
Chickens, 10	12.00
Hay for 4 horses and 2 cows from March until June, 2 tons at $15.00	30.00
Ground feed, one ton	30.00
Well, with wood pump	10.00
Store bill 12 mos. at $15.00 a month	180.00
	$1,107.00

Remarks. "Assume that he contracted for an 80 containing 65 acres of marsh and 15 acres of sandy upland. Interest and taxes to be met each year. Would estimate his drainage tax at $114, general tax about $25.00.

"Build a root house on side of sandy island. For a barn, cut poles 8 or 10 feet high, put them up vertically, board up with poles inside and outside, stuff with wild grass. Poles close together on the top for a roof, covered with small bundles of marsh hay.

"Build a house of rough lumber 16 x 20, a story and a half high, 12 foot studding, 8 feet in the clear below, leaving 4 feet at the base of the rafter with attic for storage and bedroom. Board up and paper outside with good grade of roofing felt on the sides and tops. You can buy this for about $2.50 for 100 square feet, guaranteed for 15 years, 640 feet for the roof. The roof lumber should be sized to prevent the roof from cracking. The settler can buy 2 x 4s for about $20.00 a thousand, hemlock sized $30.00. He could use either shiplap or matched lumber for sheathing with wallboard inside the house. He will need about 675 square feet of wallboard costing him not more than $30.00; six windows, $15.00; 1 door, $3.00, making a total cost of materials $250.00.

FIG. 24.—BUCKWHEAT ON BREAKING

It will grow on tough peat without much disking. It shades the ground well, keeps it moist and makes it decompose. Frost is its worst enemy, but even with crop wholly or partially lost by frost, it pays as a conditioner for tough peats.

"Native pasture is earlier than tame pasture unless you winter over your fall pasture. We figure on feeding about 7 months.

"The first year sow 6 acres of oats for hay, seeded down to timothy, alsike and red top. Red top is a good grass, very prolific and tenacious of life and in a wet season will stand more moisture than timothy or alsike. Sow 6 acres of Japanese millet. This makes better hay than German millet because it is finer. There is more forage and it is more succulent than the other variety. Cut this as soon as the seed forms and before it ripens. Do not seed this down. A low yield will be one and one-half tons to the acre.

"Three acres, six better of Ito San soybeans or early Black variety if kept for seed. Put in 3 or 4 acres of corn of a variety that has been grown locally for some time, because it is earlier and ac-

cumated. Plant about 3 feet 8 inches each way. Oats on new breaking in the spring may dry out. Put in 5 acres of buckwheat and 10 if possible. The straw has some feeding value if cut before freezing. One acre of rutabagas but work up the ground very fine, sow, and harrow afterwards. Fence in the sandy island for early and late pasture. The cattle won't get much out of it during the summer but in the spring and fall they can find some feed. Put in 6 acres of oats for hay. Cut shortly after it is headed and before it is ripe. One ton to the

Timothy and Alsike Sure

The frost does not hurt them. They can also grow in places too wet for other crops. Seed about 8 pounds of each to the acre. While it is sometimes possible to get a catch by seeding on the frozen ground in the early spring without harrowing, it is usually better to seed when the soil can be harrowed in the spring or early fall.

The best way to seed timothy is with oats and peas and cut the combination for hay before it gets ripe. Sow as much acreage as possible during the first year on fairly well decomposed peat soil.

Men operating large blocks of drained marsh land can do no better than to seed it to timothy and alsike. In fact it would be well for such men to break and seed all of their drained marsh before offering it for sale to settlers. Then if land sales are slow, there will be profit in the hay, which can be handled with less labor and risk than any other crop. It will help keep down the carrying charge to the advantage of the settler who will eventually come.

acre would be a low yield. Recommend soybeans highly. Have grown them two years, plant in rows, three-fourths of a ton to an acre will be a low yield.

"Let the corn stand as long as possible or cut at once after frost, 3 tons of dry corn fodder to the acre would be a low yield. Oats and soybeans should yield each at least 1 ton to the acre; millet 1½ tons.

"Put early potatoes on the upland. It takes them a little longer to start on the marsh and a little longer to ripen. Get good surface drainage. Tiling is too expensive until our land is worth $150.00 an acre."

Budget III.

1 team	$200.00
4 cows	160.00
Harness	50.00
Wagon, second hand	25.00
Plow, half breaker type	20.00
1 disk	45.00
Harrow, preferably wood frame because it is lighter	16.00
1 walking cultivator	5.00
Garden tools	25.00

FIG. 25.—HIDES FOR THE TANNERY

If a man wants to hunt and trap along nearby streams, he can do so. This lot of hides brought $250.

Mower	60.00
Hay rake	25.00
House 14 x 28, rough lumber, heavy felt roofing outside, no lining inside	160.00
Pole barn	
Well and pump	15.00
Store bill, 12 mos. at $15.00 a month	180.00
2 tons of hay for first feeding	24.00
Chickens	10.00
Total	$1,020.00

Remarks. "Best to have half marsh and half high land. Assume that he contracted for 80 acres. In addition to interest his carrying charges annually would be drainage tax about $80, general tax $18.00.

"No time for root crops the first year but raise 30 tons of forage crops as follows: 6 acres oats for hay, 6 acres of millet and 6 acres corn with Ito San soybeans. Longfellow flint corn best. Let beans stand for a while after corn is cut.

FIG. 26.—"BUCKWHEATS" FOR BREAKFAST

Sorghum to go with the cakes is made from the cane grown on the sandy islands.

"Put in all the potatoes you have time to plant. Put early potatoes and garden on marsh border land. No pigs at the start. Buy some buckwheat for chickens.

"After through with planting potatoes, break up some land, put in buckwheat for chicken feed. Can sow this as late as July 15th. Use early varieties for all garden vegetables. As feed for two horses the first year, from March until July 1st, ½ bushel a day of ground feed, oats and corn, two tons, $60.00.

"No tiling at the start. With fair returns the new settler should have at the beginning of the second year 4 cows, 4 yearlings, 2 horses and 18 acres of oats to be disked in, then follow the first year's system with forage crops. Fence in all upland possible for early and late pasture.

"Don't forget cumumbers as cash crop. They do well on breaking. My neighbor, last year sold nearly $200.00 worth from two acres. Build up the farm around your cows. Even a 40 acre farm might be all right here on the marsh for the man with little capital. It is possible to begin in a small way and then spread out.

"Bought my last piece this fall, 155 acres to the west of me for the taxes against it, amounting to about $10.00 an acre. 80 acres adjoining on the east is now for sale for the taxes against it. This particular 80 lacks drainage but it as good as much of the land in the southern part of this district. (Cranberry Creek)."

Budget IV.

House 14 x 28, materials	$350.00
Pole barn	
3 horses (better than two)	300.00
Wagon, second hand	40.00
Harness	40.00
Plow, regular breaker 14 inch	20.00
Disk, 6 foot	40.00
Harrow, 10 foot	20.00
Mower	50.00
Hay rake	30.00
Cultivator	25.00
Miscellaneous tools	30.00
4 cows	200.00
2 spring pigs	10.00
24 hens	25.00
Feed for stock from March to June 1, hay	50.00
Ground feed	60.00
Store bill, 12 months at $20.00 a month	240.00
Cement roller	5.00
Total	$1,535.00

Rotation and Selection of Crops

Put the crops most susceptible to frost on the better drained lands near the ditches. Put buckwheat on the tougher new breaking. Corn, rye or timothy and alsike do well where the sod is less tough. After either corn, rye or buckwheat, soybeans or truck crops do well for two years. Then seed to timothy and alsike for two years. This makes a good 5-year rotation. If a hay is to be the cash crop seed to timothy and alsike the second year and allow to remain from 2 to 5 years.

Remarks. "Carrying charges on his land in addition to interest would be, drainage taxes $80, general tax about $30.

"I have farmed on the marsh 7 years. The settler buying land in this country should take about two weeks to investigate and it will pay him to see the land twice during the season. I was disappointed because it took more money to develop my farm than I was given to believe. The settler should examine the land after frost is out of the ground. The land in this district (Little Yellow) is not all well drained. The settler should buy as close to the ditch as possible. Our land was well drained

but half a mile away the land was too wet. The new settler should see the land late in April or early in May. Land men bring prospects in during a dry season and settlers can't tell whether it has good drainage. That's the way I bought.

"Would recommend the following first year's crops:

6 acres oats and peas for hay, estimated minimum yield 3 tons.

6 acres millet, estimated minimum yield 3 tons.

3 acres soybeans, Ito Sans, estimated minimum yield 3 tons.

5 acres corn drilled estimated minimum yield 10 tons.
(frost will get the corn about 3 years out of five)

5 acres oats (seeded down) as grain for stock, minimum total yield 125 bushels.

1 acre rutabagas, minimum yield, 200 bushels.

FIG. 27.—THE SCHOOL TEACHER'S LUNCH

She is training the farmers of the future in the new school house on the marsh.

"Put the garden on the marsh-border type of soil. Use early varieties of garden crops. Put in two acres of buckwheat for chicken feed. The new settler can easily break an acre a day and he has a big advantage if he has an extra horse that he can put on for heavy work. It he has only a team and one horse gets sick, it slows up his work.

"Get your land ready for oats first. Then prepare your corn land and the land for soybeans. Buckwheat should be put in about the tenth of June, then rutabagas and millet, to July 1st.

"For fall work the first year plow new land. Three horses on a 14" plow will do a great deal more work than two. Plow at least 20 acres the first fall. Cows should take care of interest and taxes.

"In preparing land for crops use a heavy roller. Where the land was rolled, I got 20 bushels. The sod should be well worked up for potatoes. If the new settler has a surplus of feed the first winter the banker will help him get more stock. I tried out Angus cattle same as in Iowa but it didn't work well up here. One reason was because there was no market for young bulls. We raised 60 turkeys one year. They do well in this country. Bees are good.

"Of small grain crops on the marsh, oats are the best. Of other grain, crops rye is best but it will be to the settler's advantage to cut out rye altogether.

"Strawberries on the marsh may make a fair cash crop. Red raspberries, currants, gooseberries, rhubarb, asparagus, all good. Put in the garden so as to cultivate it with a horse.

"The second year if the settler has been industrious he can afford to borrow money to build a silo. He should take precautions on the

Wood Lots and Drainage

A wood lot is desirable for fuel, fence posts and rough timber.

Many sandy islands and marshes have timber that may serve these purposes. With careful selection of the site the wood lot may be conserved after drainage.

No case has been observed where the drainage of the marsh injured the trees on the upland or islands. Drainage may or may not destroy the shallow rooted tamarack common to the marshes. Near Mather in peat 10 feet in depth a ditch 8 feet deep through dense tamarack did not kill any trees outside the spoil bank. In many places the seepage of water from the sand island has kept alive the tamarack near the marsh border. But where the seepage is cut off by a ditch on each side of a marsh the water table is so lowered that the older trees find it impossible to change their habit. They die for want of water and must be cut the year after drainage to prevent waste. The younger trees on these well drained acreas are able to develop a new and deeper root system and thrive better after drainage than before. The usual precaution against fire is necessary.

marsh to guard against damage by fire by plowing around his land if possible. The peat is more subject to frost than muck. The water table should be at least 4 feet down. I would not care if it was six feet. I was deceived because I looked at the land in September and the next spring when I came there was water everywhere. I would not want to see settlers come in with the representations that were made to me. Deep peat in my opinion is a counterfeit. There is a great deal of difference between peat and muck. If the land is peat I should prefer

a depth of about two feet because if it is too shallow the fertilizer leaches through and I don't like to see the sand stirred up in plowing. The settler should not break up land on the sand islands because if you destroy the sod, sand burrs come in. He should, however, sow it to blue grass and white clover and disc. He should also fence in his garden with woven wire.

The Place for Tile

The new settler may dispense with drain tile for the first few years. Let him plow only the land so near to the outlet ditch as not to require tile. Unless there is 20 acres or more of such land on an 80 the newcomer had better look around the neighborhood until he finds an 80 that has at least 20 acres of well drained marsh on it. In the districts that have deep ditches in sandy subsoils there are areas ready for the plow. On the remainder, lines of 5" to 8" tile at the edge of the sandy islands and in pockets not well served by the outlet ditches may be put in by the farmer when his operations require more tillable acres.

Budget V.

House, 14 x 28 materials	$200.00
Team	200.00
Wagon	50.00
Harness	30.00
Plow, 14" half breaker	25.00
Disk	45.00
Harness, second hand	15.00
Mower	75.00
Rake	40.00
Miscellaneous tools	50.00
4 cows	200.00
2 spring pigs	6.00
First year poultry	10.00
Store bill, 12 months at $15.00	180.00
Total	$1,126.00

Remarks. "This does not include feed for his stock until he is able to grow it. The 4 cows should net a profit of $200 a year which would take care of his interest, drainage tax about $64 and general tax $25.

"Can keep more cows with a silo. The banker will finance a good settler for a silo.

"Soybeans good for grain or hay. Early Blacks thresh well and the straw is good for horses. Costs 25 cents a bushel to thresh them. Three horses better than two.

"Six acres of oats will make 6 tons of hay easily. Siberian millet may produce 48 bushels of seed per acre and the straw is good for horses. Have sold seed for $2.00 a bushel. Millet not hard on land. Sure of either seed or hay. Put in 5 acres of Carey or Early Evergreen sweet corn for fodder."

FIG. 28.—TILE FOR INTENSIVE FARMING

After all of the land drained by the open ditches is put under cultivation, drain out the pockets with a good drain tile. Don't lay tile any less than five inches in diameter. Send to the Agricultural College for a bulletin on tiling.

Budget VI.

House 14 x 28 materials	$200.00
Pole barn	
3 horses (he insists on this; bought locally)	250.00
4 cows (would advise him to pay a little more and get something young instead of old cows; says he should buy more cows if he is able to put up a silo in the fall of the first year; the marsh grass pasture is better today than formerly)	240.00
Harness	40.00
Wagon	80.00
Disk (for 3 horses, get a 6′ outfit)	45.00
Harrow, iron frame, 3 sections	17.00
Walking cultivator	15.00
Mower	45.00
Plow 16″ half breaker	15.00
Rake	30.00
Hay rack (materials)	5.00

Miscellaneous tools	50.00
Hay for 4 cows from date of locating March 15th to May 1st, 1½ tons	25.00
Ground feed for cows from same period	90.00
90 bushels of oats for horses	45.00
Hay for horses, 3 tons at $12.00	36.00
2 spring pigs	12.00
Sow due to farrow	30.00
2 dozen hens	24.00
Store bill 12 months at $15.00 a month	180.00
Total	$1,474.00

Can Drainage Be Too Deep

Deep drainage during the spring encourages a deep rooting of plants. Deep roots can find water even during a dry July or August. Crops that suffer during these months do so because they had too much water in the spring, rather than too little later. There may be certain ditches in each drainage district that might be dammed in the early summer with advantage, to give the plants an abundance of water while they are finishing their growth. Only after a careful study as to where such dams are needed, and feasible, should they be constructed.

Remarks. "Assume the settler contracting for 80 acres has $1,200 cash when he begins work and no payments except interest and taxes for three years. Should have at least 40 acres of drained marsh. Could not make a living on 80 acres of sandy upland alone. I believe non-resident holders are asking too much for marsh land. Suggest that home seekers look for deedable tax land. There are some good tracts obtainable in this way for about $10.00 an acre.

"Build a pole barn at first. Raise forage crops as follows; 6 acres oats, seeded down, to be cut for hay, yield, 5 tons; 6 acres millet, 6 tons; 3 acres soybeans, Ito Sans, 3 tons; 5 acres early corn for fodder, 10 tons. Have 3 tons for each cow. While getting started figure on $75 for horse feed and two tons of bran for other stock. Four cows would make enough to pay $100 a year for drainage and general taxes and $140 for interest.

"The first fall break more land for two additional cows. Fall plowing best for oats. Follow millet with potatoes and have bigger acreage of millet and soybeans second year. Fence sand islands for early and late pasture.

"Don't disturb the original sod if you want pasture. North slope of sand island best for garden first year. Recommend currants, gooseberries, rhubarb and cucumbers.

FIG. 29.—AFTER TWENTY YEARS

At first the struggle was hard because of poor drainage. This house is a monument to persistent effort and good farming on a drained marsh.

"First ditches dug in 1900 not deep enough. Were deepened to 8 or 9 feet in 1914 to 1917. Plenty of deep ditches better than tile at start. Would not tackle an 80 where the first 10 acres had to be tiled."

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Bulletin 359 January, 1924

EMERGENCY HAY CROPS

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

Emergency Hay Crops

G. B. Mortimer

FARMERS must sometimes depend upon substitute hay crops when alfalfa and clover fail.

The best emergency hay crops for Wisconsin are: Soybeans; oats and field peas; Sudan grass and soybeans; Sudan grass; millet; and oats. There is enough variety in this list for the farmer to choose the kind best suited to his needs. All of these crops are annuals; some are legumes; others are grasses; some are adapted to early seeding, and others to late seeding.

The ones best suited to early seeding are oats alone or oats and field peas. The others are adapted to later seedings, ranging from corn planting time to the first week in July. Owing to the date at which some of them may be seeded, they are also catch crops. If one of the main crops of the rotation fails, for example corn, there will usually be plenty of time to seed the field to soybeans, to millet, or to Sudan grass.

Likewise, land that cannot be planted to the earlier crops may be used for one of these. Land infested with noxious weeds, such as quack grass or Canada thistle, may be given a weed killing treatment by discing it during the early part of the season and then planting a smother crop such as Sudan grass to occupy the ground the latter part of the season. In this way a crop of hay may be secured at the same time.

Oats and Field Peas for Hay

The best early seeded grass and legume mixture for emergency hay is oats and field peas. Where the soil and climate are adapted to pea growing, this mixture is excellent. The

two crops grow well together since both should be seeded at about the same time and both are rapid growers. Any of the standard varieties of field peas will give good results, such as the Canadian, Scotch, or the Wisconsin Green. The medium late oats such as the Swedish Select, Pedigree No. 5, or the Wisconsin Wonder, Pedigree No. 1, are well adapted to grow with any of these varieties of peas, particularly the Green and Scotch varieties.

A standard rate of seeding for Wisconsin farmers is 1½ bushels of each an acre. If more peas are desired 1½ bushels of oats with 2 bushels of peas will give splendid results. The seed of the two may be thoroughly mixed and drilled in with a grain drill or seeded with a broadcast seeder. Early seedings give the best results, but since the crop is intended for hay and not for seed, the mixture may be seeded as late as the third week of May in a normal season with good results.

TABLE I—HAY YIELDS OF OAT AND PEA MIXTURES

Rates of seeding per acre		Tons of cured hay per acre				
Peas	Oats	1919	1920	1921	1922	Average
90 lbs.	48 lbs.	2.74	2.72	2.30	3.32	2.77

The best time to cut for hay is when the oats are in the milk stage. The peas are then usually beginning to develop pods. If there is much delay the hay is liable to be too straw-like since oats develop very rapidly when the seeds begin to form. If the hay is well made, it will be palatable and nutritious. Good oat and pea hay has nearly as much digestible protein per 100 pounds of dry matter as clover hay but lacks its palatability. Although not the equal of oat and pea hay in feeding value, oats alone makes a fair quality of hay if taken at the right time.

What is Sudan Grass?

Sudan grass[1] is the most recent grass crop added to Wisconsin's forage list. It belongs to the sorghum family; and

[1]Sudan grass was first introduced into this country by the Federal Department of Agriculture, Office of Forage Crop Investigations, on March 16, 1909. Since that time it has been widely distributed with the result that it has become an important hay and pasture crop in the southwestern portion of the United States. Seven years of field testing by the Agronomy Department of the Wisconsin Experiment Station has demonstrated that Sudan grass is adapted to Wisconsin conditions for emergency hay purposes.

one reason cattle relish it is because of its sweet flavor. When seeded in rows and cultivated, individual plants may grow to a height of eight feet, but when drilled in like grain or seeded broadcast, it rarely grows taller than six feet. The flowering stems are slender and bear numerous leaves. It tillers or puts forth shoots very freely. This adds greatly to the leafiness of the crop and to the lengths of time during which it may be cut for hay. A single plant when growing in a fertile soil will produce from fifty to a hundred tillers or shoots. It is an annual plant and, therefore, must be seeded each season. It is strictly fibrous rooted like the common grains, and hence is able to spread only through its seeds. Its seed head is a spreading panicle like oats ranging in color all the way from greenish yellow to a pinkish purple.

FIG. 1.—SUDAN GRASS IN FULL BLOOM

The best stage to cut Sudan grass for hay lies between early and full bloom.

Best Growing Environment

Climate—All sorghums make their best growth in a warm climate or in regions that have a relatively warm growing season. Sudan grass is no exception to this rule. In regions

where the growing season is long, from three to four cuttings may be taken. Unless grown on lighter soils, Sudan grass is not well adapted to the northern portion of Wisconsin. Throughout the southern and central portions of the state, at least one good cutting of hay may be secured and sometimes there is sufficient after growth to make a second cutting. However, it is usually best to pasture the second growth.

One of the best things about Sudan grass is its ability to withstand long periods of drouth without being seriously affected. Although its growth will be somewhat retarded, still it makes at least a fair return. Its drouth resisting ability, together with its vigorous feeding habits, adapts it to the sandier soils which are inclined to dry out earlier in the season.

Soil.—When grown upon a rich clay loam soil Sudan grass yields maximum returns. However, it will grow upon a wide range of soils from sands to clays. Upon the poorer soils it makes a better growth than most hay plants. Unlike the legumes, it is not intolerant to acid soils. Sudan grass, however, is not adapted to cold, wet soils and will produce practically no returns upon them. It requires warmth which is not found in wet, muggy soils. All such soils should be well drained before any attempt is made to grow this crop.

Growing Sudan Grass

The Right Seed Bed.—The soil for Sudan grass should be well prepared. Either spring or fall plowing gives good results. In either case harrow the soil thoroughly before seeding in order to keep the weeds down. This can be successfully done since the crop is not seeded before corn planting dates. The farmer growing Sudan grass should give it a seed bed equal to that for corn. In the case of spring plowing, it is well to compact the soil so as to firm it. This will favor both germination of the seed and root development.

The Best Seeding Dates.—As a cold soil does not favor the growth of Sudan grass, there is nothing to be gained through early seedings of the crop. Numerous trials at the experimental farms have shown that seedings made from about the middle of May up to the middle of June give the greatest

hay returns. Early seedings, made during the latter part of April or the first week in May do not seem to recover from the dwarfing effects of lower temperatures. Another serious effect of early seeding is rapid weed development due to the slow growth of the Sudan grass. Seedings have been made as late as the first week in July with good results.

How to Seed Sudan Grass.—For Wisconsin and other states having similar rainfall, Sudan grass should be broadcasted or drilled in like the small grains. Experiments show that the hay is of finer quality and the yields are usually better than when grown in cultivated rows. Furthermore, solid seeding saves the labor of cultivation. In regions that lack moisture, crops grown in cultivated rows give best results.

In seeding the crop either the common grain drill or the broadcast seeder may be used satisfactorily. Well-cleaned Sudan grass seed will feed freely through either of these machines and will be distributed sufficiently well to secure a good stand. On soils that are inclined to pack following heavy rains, care should be taken not to seed too deep. The best seeding depth is about an inch. On the lighter soils, however, the seed may be sown at a depth of from 2 to 2½ inches. Deep seeding will not cause the crop to root deeper since most of the roots form at the surface of the soil.

Rate of Seeding.—Light rates of seeding seem to give as good results as heavy rates on account of its strong tillering habit. Nothing can be said to favor rates of seeding over 25 pounds an acre. The fertility of the soil and the quality of the seed should determine the rate. On soils that will grow good crops of grain and corn, the best rate of seeding Sudan grass is about 20 pounds to the acre. Very little difference has been noted in yields of hay from 20 pound and 25 pound rates of seeding. More than these amounts are not recommended. If the crop is to be grown in cultivated rows about 24 inches apart, 5 pounds of seed to the acre will be enough.

TABLE II.—YIELDS OF SUDAN GRASS HAY PER ACRE

Acre rate of seeding	Tons of cured hay per acre							
	1916	1917	1918	1919	1920	1921	1922	Average
20 lbs.	.....	3.65	3.06	3.54	3.20	3.01	3.52	3.33
25 lbs	2.59	3.51	2.78	3.30	2.86	.....	.....	3.01
30 lbs.	.....	.....	.....	3.21	3.70	3.40	.....	3.43
Seeded in 36" rows	2.65	4.00	2.13	2.72	.....	2.94	.....	2.88

Harvesting for Hay

Sudan grass is easily made into a bright, leafy and palatable hay. In good haying weather, it may be cut in the morning and raked up the next day. Owing to the coarseness of the stems, they do not dry out as quickly as do the leaves, and unless one is careful the hay may be stacked or placed in the barns when it is still too moist. Care should be taken to see that the stems are sufficiently dry before the hay is stored otherwise heating will result. The hay may be dried thoroughly without danger of losing the leaves.

Although there is a best time to make hay, the period during which Sudan grass may be cut without suffering much in quality is longer than for the average hay grass. This is due to the numerous tillers that are successively produced and hence there is always a large amount of immature growth which adds to the quality of the hay. This feature is very important since hay crops cannot always be harvested at the right time to make the best product.

Although Sudan grass will produce a second cutting in sections where the growing season is sufficiently long, but one crop can be expected in Wisconsin. It should, therefore, be allowed to make the most desirable growth before cutting. Experiments show that the best hay and the greatest yields are obtained if the crop is taken somewhere between the time when the first heads appear and when it is completely headed. In an average season, the cutting period will be reached in about 60 to 70 days following seeding.

Sudan Grass Hay

Sudan is a heavy yielding hay grass. In this respect it clearly outranks millet as an emergency hay crop. Yields ranging from 2 to 4 tons of cured hay an acre have been secured from one cutting in Wisconsin. According to Table 1, the yield to the acre for the period indicated was somewhat over 3 tons. The hay is relished by both cattle and horses and although not the equal of clover and alfafa hay, still it makes a very desirable supplement when there are shortages of these

hays. One of the greatest objections to the hay is its coarseness, but this can be partially overcome by cutting the crop a trifle early when it is beginning to bloom.

According to Tables III and IV the hay is similar in composition and digestibility to common foxtail millet.

TABLE III.—AVERAGE PERCENTAGE COMPOSITION OF AIR DRIED HAY OF EMERGENCY HAY CROPS.

Kind of Hay	Water	Crude Protein	Carbohydrates		Fat	Ash
			Fiber	N-free extract		
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Sudan Grass	11.6	8.2	26.9	44.7	1.6	7.0
Millets	14.3	8.3	24.0	44.3	2.8	6.3
Oats	12.0	8.4	28.3	41.7	2.8	6.8
Oats & Peas	16.6	11.4	25.6	36.5	2.6	7.3
Soybeans	8.6	16.0	24.9	39.1	2.8	8.6

Eighteenth Edition of Feeds & Feeding—Table I—Henry & Morrison

TABLE IV.—AVERAGE DIGESTIBLE NUTRIENTS IN AIR DRIED HAY OF EMERGENCY HAY CROPS

Kind of Hay	Total dry matter in 100 lbs.	Digestible Nutrients in 100 lbs.			
		Crude Protein	Carbohydrates	Fat	Total
	lbs.	lbs.	lbs.	lbs.	lbs.
Sudan Grass	88.4	3.7	45.7	0.9	51.4
Millet	85.7	5.0	46.0	1.8	55.0
Oats	88.0	4.5	38.1	1.7	46.4
Oats & Peas	83.4	8.3	37.1	1.5	48.8
Soybeans	91.4	11.7	39.2	1.2	53.6

Eighteenth Edition of Feeds & Feeding—Table III—Henry & Morrison

Since Sudan grass hay practically equals millet hay in feeding value and since it makes larger yields of a more palatable hay, it is the superior emergency grass hay crop of the two wherever it can be successfully grown.

Sudan Grass for Pasture

Sudan grass can be used to supplement regular pastures. Although the crop has not been used this way to any great extent in Wisconsin, some farmers have pastured it with considerable success. They find that it is very palatable in the green state and recovers quickly when eaten off on account of its rapid growth. Moreover, it is not easily uprooted by cattle and tramping does not seem to injure it seriously. In addition, it comes on at a time when the regular pastures are beginning to fail. For these reasons, it is a desirable supplementary pasture crop.

When used for pasture, the stock should not be turned in until the grass is at least a foot high. From that time on, pasturing may be continuous, although care should be taken not to allow it to be eaten too close to the ground. If used judiciously, Sudan grass will aid materially in carrying successful pasturage through the drier months of the summer.

While this crop may be pastured with comparative safety, there is a slight danger similar to that resulting from pasturing sorghums, known as prussic acid poisoning. According to the Federal Department of Agriculture, only three authentic cases of such poisoning have been reported. In each case the poisoning resulted from pasturing the frosted crop and not from feeding the hay. The only danger seems to be when cattle pasture on a crop that has been severely affected with drouth. The best way to dispose of the aftermath or second growth of Sudan grass, the first crop of which has been used for hay, is to pasture it. It is advisable to pasture it off before severe frosts, otherwise sickness may follow owing to prussic acid poisoning.

Sudan Grass and Soybeans for Hay

The digestible protein content of Sudan grass hay is not high and for that reason it is not very satisfactory for a dairy herd. Trials with Sudan grass and soybeans gave very promising results for a hay mixture as shown in Table V.

TABLE V.—SUDAN GRASS AND SOYBEAN MIXTURES FOR HAY

Variety of soybean	Seeding rates		Tons of cured hay per acre				
	Sudan grass	Soybeans	1919	1920	1921	1922	Average
Medium Green	10 lbs.	60 lbs.	3.30	3.24	.....	.....	3.27
	10 lbs.	90 lbs.	.....	.....	4.13	3.46	3.79
Manchu	10 lbs.	60 lbs.	3.23	2.80	.....	.....	3.01
	10 lbs.	90 lbs.	.....	.....	4.34	4.69	4.51
Early Black	10 lbs.	90 lbs.	.....	.....	3.49	4.00	3.74

When seeded in a soybean mixture, Sudan grass should not be used at more than half the regular rate. Ten pounds of seed is sufficient. The later maturing varieties of soybeans for Wisconsin, such as the Medium Green, Manchu, Ito San and Mid-West, are better than early ones like the Early Black. This variety tends to lose many of the lower leaves

because it reaches more complete maturity before the crop is suitable for cutting. Although 60 pounds or a bushel of the beans have given good results, the trials show that 90 pounds or a bushel and a half of the beans give a higher yield, and the quality is better since more of the hay is leguminous. The Sudan grass in the mixture aids in curing the beans by preventing too much matting of the leaves during curing. The mixture should be cut for hay

FIG. 2.—SUDAN GRASS AND SOYBEANS GROWING TOGETHER
This makes a good emergency hay mixture; Sudan grass with soybeans adds to the yield of hay and aids in curing the beans.

when the Sudan grass is fairly well headed. It is advisable to inoculate the soybeans, particularly when the mixture is grown upon sandy soils. This combination is especially adapted to the lighter soils where the Sudan grass will not make such a smothering growth. Experiments with this mixture have shown that one third of the hay will be soybeans.

Growing Sudan Grass Seed

In southern Wisconsin, Sudan grass will set seed abundantly. Losses due to shattering are small for the heads retain the seeds very well even beyond complete maturity. If Sudan grass is intended for seed it should be sown the same as when grown for hay. When the seeds are mature, the crop should be cut. Although the plants are still quite succulent at this time, it is best to cut with a grain binder, and allow the bundles to cure in the shock. When the seed heads have thus cured sufficiently, thresh with a grain separator, taking care to regulate the air blast so that the seeds will not be blown out with the straw.

FIG. 3.—SUDAN GRASS SEED CAN BE PRODUCED IN WISCONSIN
When the seed is mature, the crop is cut with a grain binder and cured in the shock.

Good clean seed will weigh from 35 pounds to 40 pounds a bushel although weights vary from about 25 pounds to 40 pounds. The average yield of seed to an acre will vary between 300 pounds and 500 pounds. The best rates of seeding for hay yields also appear to be the best for seed yields.

TABLE VI.—SUDAN GRASS SEED YIELDS

Seeding rates per acre	Pounds of seed per acre			
	1918	1919	1920	Average
20 lbs.	451.22	426.26	327.80	401.76
25 lbs.	432.29	346.66	392.31	390.42

The question is frequently asked whether there is any danger of the soil becoming infested with Johnson grass if southern grown seed is used. Although Johnson grass grown in the south is a weed pest in many sections owing to its perennial nature and manner of spreading, it behaves strictly as an annual in the northern states, hence there is no danger whatever. Most of the seed used in the North is southern grown since the northern states have not as yet developed a Sudan grass seed industry. A slight amount of Johnson grass seed with Sudan grass seed is no great disadvantage to the northern grower.

Sudan Grass as a Smother Crop

Owing to the vigorous, rapid growth of Sudan grass both in root and top, it is an admirable smother crop for annual weeds and for some perennials, particularly quack grass. Since seeding may be delayed until the last week in June, it may be combined very effectively with a partial fallow system for the control of weeds. If the fallowing period is reasonably dry so that the quack grass is weakened, it is possible to eradicate it in a single season by following the fallow with a heavy seeding of Sudan as late as the last of June or the first week in July. This treatment may be repeated the second season, or the field may be planted to a cultivated crop like corn.

The infested field should be plowed as late as possible the previous fall to expose the quack grass rootstocks to freezing. The following spring the soil should be worked sufficiently to prevent the quack from making any leaf growth. By so doing the underground stems by which the grass spreads so efficiently are weakened and often destroyed through starvation. If the fallow is continued up to the last week in June and followed with a heavy seeding of Sudan grass, control is very effective and a crop of hay may also be secured.

Millets for Hay

Millets have been used as a hay substitute for a long time. Of the numerous forms of this crop, the foxtail varieties are best suited to Wisconsin for forage. The common foxtail millet is the superior variety for hay. It is the earliest maturing and can be made into hay when the weather is more suitable to hay making. It is more palatable since it is finer stemmed and more leafy. Millet, like Sudan grass, is a late seeded emergency hay crop. Since, however, Sudan grass outyields millet and is superior in quality it is quite probable that it will replace millet to a large extent. In every trial made at the Experimental Farm, Sudan grass has outyielded millet by at least a ton of cured hay to an acre.

Common foxtail millet may be seeded anywhere from corn planting time up to the last week in June. Earlier seedings usually fail because millet, like Sudan grass, requires a warm soil. The seed may be either drilled in or broadcasted at the rate of 3 to 4 pecks an acre, care being taken not to seed too deep.

The best hay is made from millet if the crop is cut when it is fairly well headed. Beyond this stage, the stems become hard and woody and much of the hay value is lost in the formation of seed. Millet is easily made into hay, no greater difficulty being experienced than in making timothy hay. A good stand of millet will yield at least 2 tons of cured hay an acre. Although fairly palatable, millet hay is not in a class with either soybean, pea and oat, and soybean and Sudan grass hays. It should supplement other roughages rather than be fed continuously for any period of time.

Soybeans for Hay

The soybean is the best hay substitute for the dairyman when there are shortages in alfalfa and clover. Unlike Sudan grass and the millets, soybeans are leguminous and provide a hay relatively high in digestible protein and total digestible nutrients. (See Tables III and IV.) Soybean hay ranks with alfalfa in this respect and is somewhat superior to red clover. In addition to its good qualities for a hay, a crop of soybeans, if properly inoculated, has a beneficial effect upon the soil by fixing atmospheric nitrogen.

Best Varieties for Hay

Soybean varieties for seed production are also suitable for hay. The Ito San, Manchu, Wisconsin Early Black, Black Eyebrow, Mid-West, and Medium Early Green varieties are all suited for hay production in Wisconsin. For the northern and central portions of the state, the Early Blacks are most widely used, particularly upon the heavy soils. For the lighter soils in this section, the other varieties are also advised with perhaps the exception of the Medium Greens and the Mid-Wests. In the southern portion of the state, Manchus and Ito Sans are well adapted to heavy soils, while upon the lighter soils, later varieties such as the Medium Greens and Mid-Wests are excellent.

Growing Soybeans for Hay

Soybeans are not a difficult crop to grow for hay. No legume is so widely adapted to various soils. Soybeans grow well on both heavy and light soils and are valuable for very sandy soils. The crop is not sensitive to an acid soil and so may be profitably grown without liming. Even well drained marsh soils will grow soybeans successfully.

For best results, soybeans should be planted about the same time as corn. They may be seeded with success up to the third week in June. If, following the removal of early canning peas, the soil is disced and seeded to soybeans by the first of July, a fair yield of hay may sometimes be secured. The early plantings are best, however, since the crop grows better during the early part of the season and reaches maturity when the haying weather is most desirable.

Soybeans for hay may be either seeded in cultivated rows like corn or drilled in like grain. On heavy soils, the latter method is usually preferable, while upon the lighter soils seeding in cultivated rows should be more frequently practiced, since on these soils the crop seems to do better under cultivation. Planting in rows requires from one-half to three-quarters of a bushel of seed an acre. For a drilled-in crop the amount of seed for an acre varies from one and one quar-

ter to two bushels depending upon the size of the seed and the fertility of the soil. The corn planter, set either at the regular width for corn or narrowed up as desired, may be used for row planting.

FIG. 5.—SOYBEANS GROWING IN CULTIVATED ROWS
Soybeans may be grown in cultivated rows, particularly upon soils where weeds are bound to give trouble.

Soybeans should not be planted too deep, particularly on heavy soils, otherwise the plants may not come up well. From an inch to not more than an inch and a half is usually deep enough. The seed should be inoculated with soybean culture before planting for best results.

Every precaution should be taken to protect broadcasted or drilled-in beans from the weeds. Two good practices may be used. First, since soybeans are a fairly late seeded crop, many of the weeds may be destroyed by keeping the soil well worked previous to planting. Second, either the light harrow or the weeder may be used effectively without much injury to the crop when the plants are from 2 to 6 inches high. The best time to do this is in the afternoon of a sunshiny day. The plants are then limp or more wilted and the harrow will pass through readily without breaking them off.

Making Soybean Hay

Soybeans should be cut for hay before the lower leaves start to fall. At this stage, the lower seed pods are well formed and partially filled. Delaying beyond this stage produces a hay with woody stems which cattle refuse to eat. Soybean hay is not difficult to make if the weather is at all favorable. The crop should be cut with a mower when the dew has dried off and then allowed to thoroughly wilt in the swath. Every precaution should be taken to preserve the leaves since they have the greatest feeding value.

FIG. 6.—MAKING SOYBEAN HAY

Largest yields and hay of best quality are obtained by cutting soybeans when the lower pods are well formed.

Following the wilt in the swath, soybeans should be raked into windrows and if sufficient labor is available, made into small cocks and allowed to cure until fit to store. This will make the best grade of hay. Before it is stacked or stored in the barn, the hay should be thoroughly dry. The cocks should be turned over and allowed to dry for a few hours before hauling. However, in handling large acreages with limited labor, a fair grade of hay can be made directly from the windrow.

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Strawberry Culture in Wisconsin

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN, MADISON

Strawberry Culture In Wisconsin

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THE STRAWBERRY is the most important small fruit grown in Wisconsin, both commercially and for home use. The reasons for its great popularity are, ease of culture, earliness, short period between planting and fruiting, comparative freedom from pests, adaptability to varying conditions, and the great popularity of the fruit itself. It is grown for home use in all parts of the state. Commercially it is largely confined to areas reasonably near large markets, but in a few sections it is produced strictly for wholesale markets.

Choose Plantation Site Carefully

The selection of the site has much to do with success, particularly where this fruit is grown commercially. It is an important factor in earliness and prevention of injury from late spring frosts. If exceptionally early fruit, which brings maximum prices, is desired, safety

To Succeed With Strawberries

Select site for plantation with care.

Prepare the soil thoroughly.

Keep the soil fertile.

Plant adapted varieties.

Use only good plants.

Set plants properly.

Keep the soil thoroughly tilled.

Protect plants and fruit by using a mulch.

Place only good fruit on the market.

Make the package attractive.

from frost injury must be sacrificed to a considerable degree. For such a crop select a site with a southern exposure and preferably with a light soil. If earliness is not of prime importance, choose a northern slope to retard the flowing period, which lessens the danger from injury from late frosts, and causes later ripening of the fruit. The slope should be gentle so as not to favor serious soil washing. The selection of the site for the home plantation is not so important. Nearness to the house is usually of more importance than either earliness or greater safety from frost injury.

Select as Good a Soil as Possible

There is no one "best soil" for strawberries. The crop is grown commercially on soil of practically all types, ranging from rather light sands to heavy clay and black prairie loams. On each, excellent results are secured if proper cultural practices are followed and the right varieties grown. For commercial plantations, a deep, rich, well-drained sandy loam is usually preferred.

Certain qualities are necessary in any soil if good results are to be secured. Ability to retain moisture is of first importance, as the production of heavy crops demands large amounts of moisture. Ordinarily rains at fruiting time are insufficient for the needs of the crop. This is especially true if the greater part of the spring rains has run off instead of being absorbed by the soil. The soil should be in condition to catch and hold the moisture. The ability of the soil to do this depends upon its texture, organic content and physical condition. Water runs off a soil with compact surface. Lumpy, cloddy soils lose their moisture much more readily than those of fine tilth. Decaying vegetable (organic) matter in the soil increases its water-holding capacity. Soils which do not and cannot be made to possess these requisites should be avoided in selecting a site for growing strawberries.

The plant-food content of the soil should not be overlooked. Comparatively fertile soils are most desirable. If a soil is ideal in other respects, however, deficiency in plant food should not deter one from selecting it for a strawberry plantation, as such deficiency can be overcome.

If a soil selected does not contain a liberal amount of decaying vegetable matter, it should be applied in preparing the soil to receive the plants. Such material, in addition to influencing the water-holding ability of the soil, bears an important relation to its productiveness. This is one of the reasons why new land gives such satisfactory results when planted to small fruits.

Good drainage is necessary. While an abundance of soil moisture is advantageous, an excess is very harmful. The water table should be a sufficient distance below the surface to allow for good root development. It should also be possible for excessive soil moisture to be carried away readily.

Thorough Soil Preparation Pays

Good soil preparation will repay the grower in lessened work later on and usually produces larger crops of finer fruit than if it is poorly done.

Four things in particular need to be taken into account in preparing the soil. These are: the control of pests; the plant food and organic matter content of the soil; and the tilth. Preferably the tract chosen should have grown a cultivated crop one or two years before being planted to strawberries.

The cultivation lessens the danger of injury from the white grub; weeds are less likely to prove troublesome; and a good tilth is more easily secured under such conditions. If it is necessary to use sod land it should be spaded or plowed during the summer or fall previous to planting so as to give as much chance as possible for the sod to rot.

Liberal amounts of plant food are essential to the production of large crops. There is little danger of getting a strawberry soil too rich. In practically all cases it will be desirable to increase the plant food at the time of preparing the soil. Most growers prefer to use well rotted manure for this purpose. It is usually more economical to supplement the manure with commercial fertilizer. If necessary to use coarse (unrotted) manure, it should be applied in preparing the soil for the crop preceding the strawberry. If fairly well rotted it may be applied the fall preceding setting of the plantation and plowed under. Well rotted manure is ordinarily applied before plowing in the spring. If very fine, it may be used as a top dressing after plowing and worked into the soil.

No Set Rule To Follow

So much depends upon the natural fertility of the soil and its previous cropping and fertilization that no general formula for the application of fertilizer would apply in all cases. Growers will find it necessary to determine largely for themselves by field trials what is lacking and then increase the element or elements which are deficient.

The amount of manure used varies greatly. The average application is from ten to twenty tons or loads per acre. Some growers use as much as forty loads per acre. It would seem to be more economical, in most cases, to use a smaller amount and supplement it by using commercial fertilizers. Possibly a better way to determine the amount of manure to apply would be on the basis of the organic matter needed. Under this method enough manure would be put on, if available, to give the desired amount of organic matter. It would then be supplemented, if desirable, with from 200 to 400 pounds of acid phosphate and possibly 50 to 100 pounds of nitrate of soda or sulphate of ammonia.

Some growers prefer a complete commercial fertilizer either used alone or supplementing the manure. A fertilizer containing 3 per cent

nitrogen, 7 per cent phosphoric acid and 9 per cent potash, called a 3-7-9 mixture is usually chosen. A mixed fertilizer of this composition may be bought but where considerable quantities are needed, it is usually more economical to purchase the materials carrying the desired elements and mix them at home. When used without manure it is a good plan to have the nitrogen carried in two forms—one in which it is readily available and the other more slowly available.

It is impossible to state just what amounts would give best results, but Table I is suggestive of the quantity of various common fertilizers which will furnish desired amounts of plant food.

TABLE I.—SOME FERTILIZERS AND SUGGESTED RATES OF APPLICATION

Fertilizer	Per cent strength	Pounds per acre	Pounds element
Nitrate of soda	15 N	100-200	15-30 N
Sulphate of ammonia	20 N	100-200	20-40 N
Dried blood	14 N	200-300	28-42 N
Muriate of potash	50 K_2O	100-200	41-82 K
Sulphate of potash	48 K_2O	100-200	40-80 K
Bone meal	21 P_2O_5	250-400	23-37 P
Acid phosphate	15 P_2O_5	350-500	23-33 P

N—Nitrogen; K_2O—Potash; P_2O_5—Phosphoric Acid;

K—Potassium; P—Phosphorus.

In mixing these materials to make the 3-7-9 fertilizer recommended it is possible to adjust the proportions in various ways. To indicate how the problem may be solved two such mixtures are shown in Table II.

TABLE II.—SUGGESTED FERTILIZER MIXTURES

Fertilizer	Per cent strength	Amount in pounds	Pounds of plant food
Mixture I			
Nitrate of soda	15 N	100	15N
Acid phosphate	15 P_2O_5	225	35 P_2O_5
Sulphate of potash	48 K_2O	95	45 K_2O
Mixture II			
Dried blood	14 N	150	21 N
Bone meal	21 P_2O_5	125	49 P_2O_5
Muriate of potash	50 K_2O	180	63 K_2O

In these formulas if nitrogen is to be carried in two forms, approximately equal amounts of nitrate of soda or sulphate of ammonia and dried blood should be used. Choice cotton seed meal can be substituted for dried blood. To give the same amount of nitrogen, double the amount of cotton seed meal should be used.

There is practically no danger of increasing any of the elements to an injurious extent except nitrogen. An excessive amount of this element has a tendency to cause heavy vegetative growth at the expense of fruit production. When used as supplementing manure, the amount of nitrogen may be reduced. In doing this it is probably best to leave out the less readily available form.

Commercial fertilizers should be put on after plowing and thoroughly mixed into the soil.

Do Not Neglect the Organic Matter

Increased amount of plant food in the soil is of little value to plants unless there is an abundance of organic matter present. Frequently so-called poor soils have sufficient plant food but are unproductive because of insufficient organic matter. As previously pointed out, the use of manure is the common method of increasing the organic matter content of soil. If sufficient manure or similar litter cannot be secured then it is necessary to resort to green manuring. Any crop which produces a large vegetative growth in a relatively short period may be used. When leguminous crops are grown for green manuring the nitrogen content of the soil is also increased. Some growers supply organic matter largely by growing clover in the rotation in advance of the cultivated crop preceding the strawberries.

Good Tilth is Very Important

Soil which is to be planted to strawberries should be plowed or spaded fairly deep. The heavier types of soil should be plowed deeper than the lighter ones. Fall plowing is desirable particularly on heavy soils. When this is done discing or shallow plowing should be the first tillage operation in the spring.

Thorough harrowing, planking, or other cultivation should follow to put the soil in as fine tilth as possible. It is particularly important that the upper two or three inches be loose and friable in order that planting may be facilitated and soil moisture conserved. Some soils may be so loose and open as to make rolling desirable. If done, it should be followed immediately by harrowing to retard the escape of moisture.

How to Select the Plants

Good plants are necessary for the best results. When the plants for the new plantation are bought, there is little chance for selection but on the other hand, if the grower takes the plants from an old plantation, he can carefully select them. Three things largely determine the desirability of a plant: Age, character of the root system, and freedom from pests.

The plants should be strong and vigorous, arising from runners of the same season or in the case of spring planting from the season previous to the time of planting. Old, fruited plants **should not** be used. It is desirable to have a plant with good top growth. It is more important, however, that it possess a good root system. A plant with a large healthy root system and a comparatively small top is much to be preferred to one in which these conditions are reversed. The former will soon develop a large top while the latter will find much difficulty in putting out new growth.

FIG. 1.—ONLY STRONG PLANTS ARE WORTH PLANTING

The plant at the left is too young and weak.

Care for the plants properly on their arrival. Neglect at this time frequently results in failure to get a good stand. Often plants are shipped long distances or are delayed in transit and so arrive in poor condition. Lack of proper attention means a loss of the plants, as well as time and labor. Even plants arriving in good condition deteriorate rapidly if not properly cared for.

Remove the plants from the package as soon as they are received and heel them in. This process consists in placing the plants in the soil in loosely compact rows. Select a location protected from sun and wind. Spade up the soil, putting it in the same condition as it would be if the plants were to be set permanently. Make a broad V-shaped trench about eight inches deep. Open the bundles and distribute the plants along the trench just far enough apart to allow the root system of each to come fully in contact with the soil. Refill the trench, compressing the soil, being careful that the crowns are not covered nor the upper part of the roots exposed. Place the variety label at the end of

the row to avoid any danger of mixing varieties later on. Water the plants thoroughly after heeling-in. If early in the spring, the plants should be mulched to prevent injury from freezing and in this way may

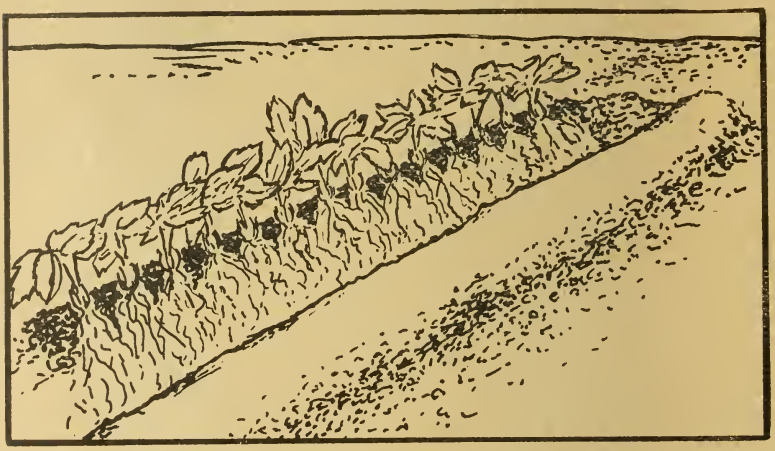

FIG. 2.—HEELING-IN SAVES PLANTS AND DISAPPOINTMENTS

Plants should be properly heeled-in as soon as received.

be kept for some time without being injured. However, the length of time they are left heeled-in should be as short as possible.

Spring Planting Usually Best

Spring planting is usually more successful under Wisconsin conditions. Sometimes home plantations are set in August or early in September, so that fruit may be harvested the next season. This procedure is questionable and in commercial plantings is to be discouraged.

The systems of setting plants vary with the extent of the plantations and the whims of the grower. Three more or less distinct systems of planting and various modifications of these are in use. They are the hill, hedge row, and matted row systems. The matted row is used almost entirely in this state. In this system the runner plants are spaced about 6 to 8 inches apart until they take up the entire area devoted to the row.

The distance between plants in the row varies primarily with the ability of the plant to produce runners and the system of planting. Except in the hill system, it is most largely dependent upon the ability of the plant to produce runners. Some varieties, like Senator Dunlap

and Sample, throw out numerous long runners and will need to be planted farther apart than the Bubach, Chesapeake and other shy plant-makers. The distance between plants in the row varies from fifteen to thirty inches. The most common distance is 24 inches.

System of planting and method of tillage determine the distance between rows. Where hand tillage is practiced, rows in the hill and single-hedge row systems may be 30 inches apart. Thirty-six inches is about the minimum for the double-hedge row and matted row. Where horse cultivation is used, these distances will need to be increased 6 to 12 inches. The usual distance for the matted row, when horse cultivation is used, is 3½ or 4 feet.

The number of plants required to set an acre varies with the distance of planting. Table III gives the number for various distances of planting.

TABLE III.—NUMBER OF PLANTS PER ACRE PLANTED IN HILLS, DOUBLE-HEDGE, AND MATTED-ROW SYSTEMS

Distance between		Plants
Plants	Rows	
Inches	Feet	
15	3	11,616
15	3.5	9,955
15	4	8,712
18	3	9,680
18	3.5	8,298
18	4	7,260
24	3	7,260
24	3.5	6,223
24	4	5,445
30	3	5,808
30	3.5	4,979
30	4	4,356

In planting it is desirable to have the field marked out in at least one direction. If marked in one direction only, it probably should be done at right angles to the direction of the row as this gives the location of the plants in the row. The rows may be kept straight by the use of a garden line. Care should be exercised not to crowd the line out of place as crooked rows result. Some growers place the line 6 inches to one side of the place where the plants are to be set and then measure with the spade or trowel for the exact location of the plant. This prevents difficulty arising from the shifting of the line. Some growers mark the rows and estimate the proper location of the plants in the row.

In large plantations marking both ways is preferable. There are several ways of doing this, the most common being an especially con-

structed sled or pole marker of the corn-marker type, but with adjustable runners or pins. It is preferable to have rows run north and south whenever possible as this provides an equal distribution of sunshine to both sides of the row.

Prune Before Planting

Pruning is usually necessary before setting the plants. It consists in reducing the top and shortening the roots. Top pruning is usually done at planting. All dead leaves, and the greater portion of the live ones should be removed. Only one or two small, healthy leaves should be left, as they are sufficient for the needs of the plant at that time, a much larger number being likely to prove injurious by causing too much transpiration. Root-pruning consists in cutting off the ends of the roots, leaving the roots three to four inches long. The roots should be kept as long as possible and still not interfere too seriously in planting. This operation is performed when the plants are heeled-in or just before the setting. If plants are to be left heeled-in for a considerable time, it is better to defer the root pruning until planting time.

FIG. 3.—UNPRUNED AND PRUNED PLANTS

Pruning facilitates planting and enables the plant to get a better start.

Exercise Care in Setting

Three things are essential in setting strawberries: (1) The plants must be set at the proper depth; (2) the soil must come in firm contact with the roots; and (3) the roots must not be allowed to become dry during the setting.

The plants should be so set that the soil covers the base of the crown of the plant. Deeper planting covers the crown, and the bud may not be able to push out of the soil. Shallower planting exposes the upper portion of the roots and the plant is killed by the roots drying out. The soil should be pressed firmly against the roots so as to bring all points in contact with the soil. If this is not done, the plant is unable to secure enough water to sustain life. In order to bring all

parts of the roots in contact with the soil, they should be spread out as much as practicable. Good results can be secured without spending additional time to spread out the roots.

To allow the roots to dry out during planting is usually fatal. Provision should be made for keeping them moist at all times. This is usually done by putting the plants into a pail of water or by wrapping them in a wet cloth. Sometimes a boy is employed to drop the plants ahead of the men who set them. If this method is followed, it is very important to see that the boy is not more than two or three plants ahead of the planter at any time.

FIG. 4.—SET PLANTS AT PROPER DEPTH
Left—Plant set too deep. Center—not deep enough. Right—correct depth.

Methods of Setting

Methods of setting vary somewhat. The trowel or dibble and spade methods are commonly used. In some cases, on light soils in extra good tilth, the opening for the plant is made with the hands. Some growers prefer the spade, while others will have nothing but the dibble, claiming that it is more rapid and insures better work. Either method is satisfactory if care is exercised in doing the work, but neither will give good results if the work is carelessly done. When setting large acreages some growers use a planting machine such as is used in setting cabbage or tobacco.

In dibble planting each planter works independently. The dibble is thrust into the soil and by a sidewise movement an opening is made for the plant. The roots are thrust into the opening, lowering the plant somewhat below the height it is to stand. It is then raised to its permanent position so that the roots may be well spread out and placed naturally instead of being crowded into a bunch. The dibble is then thrust into the soil at a slight distance from the plant and soil is

FIG. 5.—PLANTING WITH A DIBBLE

Considered by many the best method of setting plants.

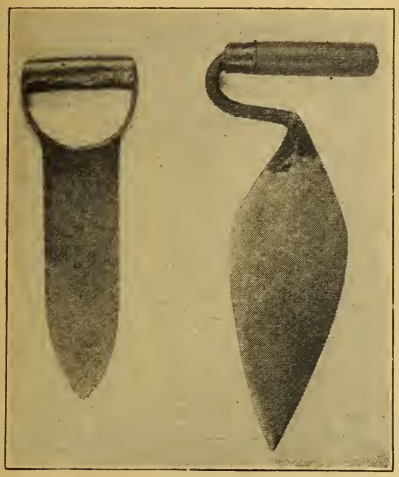

FIG. 6.—SOME GOOD DIBBLES
The dibble is an efficient implement for setting strawberries.

crowded against the roots. The second opening is filled by knocking loose earth into it. In dibble planting, the men usually work in teams of three. One drops the plants; the other two set them.

When planting by the spade method two men work together, one to handle the spade and one to prune and place the plants. A smooth, bright spade is necessary, as the soil will stick to a rusty one. The spade is thrust into the soil from two-thirds to three-fourths the length of the blade. In this operation the back of the spade is away from the operator. By a forward and backward movement an opening is made in the soil. The spade is then either wholly or partly removed, depending upon how great a tendency the soil has to fall into the opening. The man who places the plant, working on the opposite side of the row, grasps the plant between his thumb and the palm of his hand, and using fingers to spread the roots, insets them into the opening with a sort of swinging motion. The spade-operator again pushes the spade into the soil this time two or three inches from the plant and presses soil against the roots. Meanwhile the man who places the plants presses the soil on the opposite side of the plant with his foot which insures a good contact between the soil and roots. As with the dibble method, the second hole made in planting is then filled.

FIG. 7.—SPREAD ROOTS
An easy method of accomplishing this result in spade planting.

Care Needed After Planting

Cultivate immediately after planting in order to: (1) Conserve moisture, (2) increase the available food supply; and (3) destroy weeds which affect both moisture and food supply.

The conservation of moisture during the summer months following

planting is the most important result of proper cultivation. If the soil is left compact after planting, or allowed to become compact during the summer, the loss of soil moisture takes place rapidly and in such quantities that the plant soon reaches a point where further growth is reduced or entirely checked. No matter how much available plant food may be present in the soil, without soil moisture the plant is unable to use it. Cultivation, therefore, must be of such a nature as to provide the most effective means of conserving all the soil moisture possible. If this be done, plant food will be made available and weeds will be kept down.

The best practical means of conserving soil moisture is by maintaining a soil mulch of one or two inches on the surface. To do this, frequent cultivation is necessary. The soil should be stirred at least once every ten days or two weeks and following each rainfall which compacts the surface soil. Cultivation should take place as soon after a rain as the soil will permit. The cultivation should be shallow. A soil mulch of one to two inches is effective in conserving moisture, and as the strawberry is a shallow-rooted plant, deep cultivation might severely injure the root system. Cultivation should be in two directions if possible until the runners begin to form, when it must be confined to one direction. Hoe about the plants immediately after planting to loosen the surface of the soil. Other hoeings may be given with profit if time permits. The stirring of the soil should continue throughout the season or until the plant has practically ceased growing.

Grow Plants First Season

The fruiting of plants during the same season as planted or the first season after planting, if set in the fall, is to be discouraged, except in home gardens and with everbearing sorts. The plants should exert all their activity the first year in producing good vigorous crowns and strong runner plants. In order to conserve all the strength of the plants for this purpose the buds or blossoms should be removed as soon as possible after being formed.

Runner plants should be selected as soon as possible and given conditions which will insure quick rooting. Their distribution will depend upon the system of planting in use. In matted rows the plants should be kept from six to eight inches apart to prevent the rows becoming too thick. The amount of time which can be profitably spent placing runners will depend quite largely upon the cost of available labor.

Why Mulch Strawberry Beds?

Mulching is one of the essentials of successful strawberry culture. In Wisconsin its chief uses are to prevent heaving of the plants in

spring and to keep the fruit clean. These make the use of mulch imperative in a majority of instances, but there are other advantages to be gained by its use. Moisture is conserved during the spring months, the weeds are kept down, fruiting may be retarded somewhat if desirable, and the soil is kept from baking.

A good mulch should be free from weed seed, spread evenly and break up readily in the spring. Various materials possess more or less fully these desirable qualities. Wheat or oat straw; coarse, strawy horse manure; and marsh hay are the three in most common use, although any one of these may be objectionable if it has too many weed seeds. Marsh hay if cut at the proper time is less likely to have weed seeds, but in any case the hay should be cut before the seed ripens enough for germination, or before it becomes very objectionable. Neither marsh hay nor manure break up in the spring so well as wheat-straw, but the manure has the advantage of adding plant food. Oat straw is frequently too foul with weeds to make a good mulch. Shredded corn stalks and pine needles are sometimes used for mulching.

The mulch is usually applied in the fall. Most growers wait until the ground is frozen permanently; others apply it shortly before freezing, claiming that there is less danger of injury to the plants due to alternate freezing and thawing. In the northern part of the state, where heavy falls of snow come early and remain on the ground during the winter, growers frequently do not apply the mulch until spring. It is doubtful if this is the best practice.

The depth of the mulch will vary with different conditions. If applied in the spring, it may be distributed thinly over the rows. In the fall it should be heavier so as to prevent alternate freezing and thawing of the ground in the spring. It should not be so thick, however, as to smother the plants. The usual depth under Wisconsin conditions is two to four inches after the mulch has settled.

When to Remove Mulch

The time of removing a mulch, applied in the fall, depends upon the seasonal conditions and the time the fruit is desired. As the chief object is to prevent the heaving action of alternate freezing and thawing, the mulch should be left until such danger is past. It is also well to leave the mulch long enough to retard blossoming sufficiently to escape late frosts. If it is desirable to use the mulch as a means of retarding the ripening of the fruit, the mulch may be left until the plants begin to push a few leaves up through it. It should not be left so long, however that considerable growth takes place beneath it. If early fruit is desired, remove the mulch as early as possible, even taking some chances of injury from late frosts.

If the mulch be a light one, about all that is necessary is to loosen it somewhat so that the plants will be able to grow through it. If heavy, it is necessary to rake off a portion and place it between the rows. Occasionally, where the space not occupied by plants is small, it may be found necessary to remove part of the mulch from the field.

It should be remembered that all the mulch should not be removed from the plants. The plants should grow up through enough mulch to keep the ripened fruit from coming in contact with the soil. There is no sale for dirty or sandy berries. Do not leave chunks of mulch over the plants, as this will cause injury.

Some growers practice cultivation from the time the soil is fit to work until the berries are half grown. In such cases the mulch removed from over the rows must be hauled off and replaced again at fruiting time. This, however, is not the common practice, as the average grower lets the mulch conserve the moisture and keep down the weeds until after fruiting.

Caring for the Crop

Harvesting seems to be one of the most trying operations of strawberry culture, primarily because of the difficulty of getting reliable pickers. If the strawberry is to reach the market in a salable condition, it must be handled carefully and with the utmost attention to details. It is difficult to get the average picker to realize the importance of these things. The strawberry is a very tender fruit and should be picked by pinching off the stems, but the stems should not be left long. Pulling the berry from the plant should not be allowed, as many berries are partly crushed or the stem and calyx pulled out, both of which result in rapid deterioration and failure to stand up well in transit.

Supply the picker with a carrier holding from four to six boxes. When the picking is good, the larger number is not too many, but when the fruit is ripening slowly and it requires some time to pick a boxful, fewer boxes should be picked before taking them to the packing-shed. It should be the aim to get the berries into the shade as soon after they are picked as practicable. If left to stand in the full sunlight, a box of berries is spoiled in a very short time.

Some growers attempt to have their pickers grade the berries when picking. This is practicable only when the pickers are above the average or the fruit exceptionally uniform, and is not satisfactory if a grower is building up a reputation for superiority. The average boy or girl who picks berries is not to be trusted to sort or grade them. In most cases, therefore, it is more satisfactory to have the pickers give no attention to this matter and provide an additional force to grade and pack the fruit.

The question of how ripe the fruit should be when picked is one which bothers many growers. Varying conditions make it impossible to give a definite rule. Much depends upon the distance the fruit must be transported before reaching its destination. For home use, the berry should be allowed to become fully ripe, as then it will have a better flavor. If designed for the local market, the fruit should be

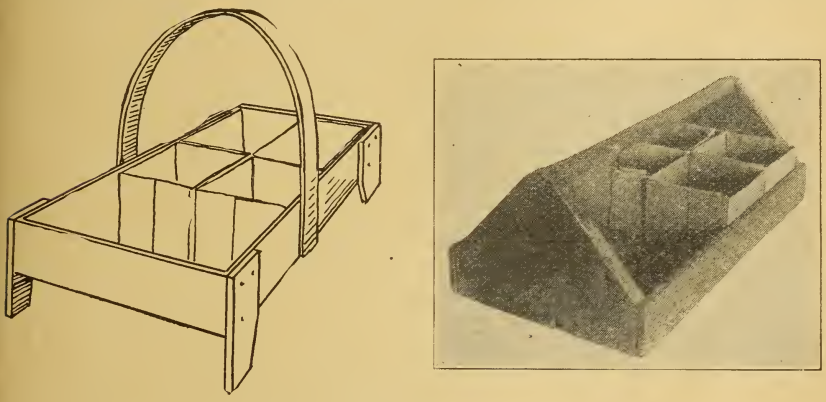

FIG. 8.—TWO TYPES OF CARRIERS

The carrier facilitates harvesting. When picking is poor, reduce the number of boxes given the picker at any one time.

entirely colored, but showing light at the tip and on the lower side, while for distant markets the berries should be red on the exposed side, and pink or slightly white on the underside or at the tip. In order to secure fruit of the right degree of ripeness, pickings must be frequent. As a rule not more than one day should intervene between pickings, and if the weather is hot and the berries are ripening fast, picking every day is better if practicable. Fruit should not be picked, however, when wet.

Just how much additional time should be spent in sorting, grading, and packing the fruit depends upon the individual grower or the exchange through which the fruit is handled. Some sorting and grading is always necessary if a good, attractive product is to be placed on the market. A good sorting table may be made of a piece of cheese cloth fastened to a frame. Where careful grading and packing are done, one packer can take care of the fruit from three pickers.

Handling the Bed after Harvest

The permanence of the bed is a question upon which it is impossible to get growers to agree. Some growers harvest but one crop from a field while others take as many as three. In beds for home

use this number is exceeded at times. The number of crops which it is profitable to harvest from a plantation depends primarily on the question of whether the plants are in good condition and whether or not it will be cheaper to renovate the old bed than to start a new one. Both of these factors depend largely upon the care that has been given the field. If careful attention has been given to thinning out the plants, keeping pests in check, preventing the weeds from seeding, and adding

The following rules for picking and handling strawberries are in force in one of the western fruit exchanges.

(1) Berries must not be picked while there is moisture on plants

(2) Berries should be pink all over, or three-fourths red

(3) Berries should be picked riper in cool weather than in warm

(4) A picker must not be allowed to hold more than one or two berries in his hand at the same time

(5) Filled carriers must not be allowed to stand in the sun

(6) Berries must be picked with a stem a quarter of an inch long and not longer or shorter

(7) Sort out all green, over-ripe, misshapen, and small berries

(8) No culls in boxes. Put in nothing but fair-sized berries

(9) Use clean crates and keep them from being soiled

(10) Haul in spring wagon and cover to keep out the dust

plant food, a larger number of crops may be removed than if these matters are given only ordinary attention. Weeds play an important part in the consideration, and as a rule the difficulty with which they are controlled makes it inadvisable to crop more than two years. As indicated above, some growers harvest but one crop, claiming that it is cheaper to start a new plantation than to renovate the old one. Those who harvest two crops claim larger yields for the second crop than for the first.

Renovating the old bed is essential if a second crop is to be harvested. This operation differs with different growers and with

different systems of planting. As the matted row is the most common form in Wisconsin, directions for renovating will be for plantations of that system.

Mow and Destroy Old Foliage

Developing strong new growth is an important consideration. As a considerable portion of the foliage has become more or less injured during harvesting and is likely to be infested with both fungous and insect pests, it is usually desirable to get rid of the old foliage and permit new to develop. The most economical method of removing the old growth seems to be to mow the patch. This can be done very efficiently with a mowing machine with the cutter bar tilted up in front only enough to prevent digging into the ground. Some growers dispose of the portion removed by burning over the patch. The mulch which is left between the rows is stirred up and with the leaves is allowed to dry. When in a good burning condition, fire is started on the windward side of the field on a windy day, the object being to burn over the patch quickly. Slow burning of piles of leaves or litter over the plants causes injury to the crowns. When there is difficulty in getting the fire to run well the leaves and litter may be raked between the rows and burned. Some growers rake up the leaves and coarse mulch with a horse rake and haul them off the plantation.

Narrowing the rows is the second operation in renovation. This may be accomplished by plowing a furrow down either side of the row, throwing them away from the row, or by running twice between the rows with a two-horse cultivator. In this way the row may be cut down to the width desired, which usually is from eight to twelve inches. On heavy soils difficulty is sometimes experienced in plowing or cultivating between rows because of the compactness of the soil due to tramping during harvest. There seem to be only two things to do in such a case, irrigate or wait for rain. The narrowing of the rows should be followed by harrowing in the direction of the plowing and then across the rows. The beds may be gone over several times until the soil is in ideal condition. For this purpose, a spike-toothed harrow with teeth slanting back is preferable, although a weeder may be used with fairly good results.

Fertilization may be accomplished at this time by distributing well-rotted manure over the rows and by cultivating or plowing in a liberal amount between the rows. A small application of nitrate of soda—one hundred pounds per acre—may be also applied to hasten new growth, but plants should not be allowed to become too thick. With the beds in this condition, cultural methods are the same as for the first year.

Strawberry Pests

The common pests of the strawberry are the leaf-spot disease, the white grub, the strawberry leaf-roller, the strawberry aphis, and the weevil. All pests are most easily controlled when the location of the plantation is changed frequently.

The leaf-spot, or strawberry blight, appears as round reddish-brown or purplish spots on the foliage. Usually it is not a serious pest. When it becomes troublesome it can be controlled by spraying with Bordeaux mixture. Usually an application just before blossoming will hold the disease in check. At times it may be desirable to make an application as soon as growth starts and also one immediately after blossoming.

Cutting off and burning the old foliage is helpful on plantations to be fruited a second time. If the disease appears on the new growths an application of Bordeaux should be made.

The white grub is frequently a serious pest of strawberries in Wisconsin. It attacks the plant just below the crown, severing the top from the roots. Its presence is first noticed by wilted plants which when picked up are free of roots. There is no very satisfactory remedy for this insect. Avoid newly plowed sod land.

The adult leaf roller lays its eggs on the leaves early in the spring. The newly hatched larva feeds for a short time on the leaf, then draws the leaflet together with a silken thread and feeds upon the leaflet from within. Spray with three pounds of arsenate of lead to fifty gallons of water at the first appearance of rolling of the leaves. This may be followed by another application a week to ten days later. Moving off and burning the leaves after harvest also aids in its control. A bed which is not to be fruited a second time should be plowed under immediately after harvest.

The strawberry aphis or foot louse is a common pest in this state. As it works beneath the surface, it is not easily detected. Ants working around the base of a weak plant are the best indication of the presence of this pest. The presence of ants does not always indicate that the plants are infested, nor are the ants always present where the aphis is to be found.

The first attempt to control root aphis should be the taking of precautions against infestation from outside sources. Persons securing stock from such sources should dip the plants just before setting, in an eight per cent kerosene emulsion or a solution of nicotine sulphate, one part to one thousand. The plants should be left in this solution ten to fifteen minutes. If the plantation is badly infested, little can be done to eradicate the pest and it is probably best to start a new plantation on another site. Burning over late in the fall is beneficial.

The strawberry weevil is the least common of the pests mentioned. This insect does its damage by puncturing the bud of perfect varieties

and laying an egg in the interior. The flower stem is then partly cut in two so as to check further development of the bud. This cutting causes the buds to wilt and later to fall off. Where the insect is troublesome the planting should consist largely of imperfect varieties. Only enough perfect flowered plants to insure pollination should be set. The perfect flowered variety chosen should be a profuse bloomer.

Cross-Pollination Is Important

Several factors must be considered in the selection of varieties. It is quite as essential that sexual union take place for the production of a crop of berries as it is in securing offspring from animals.

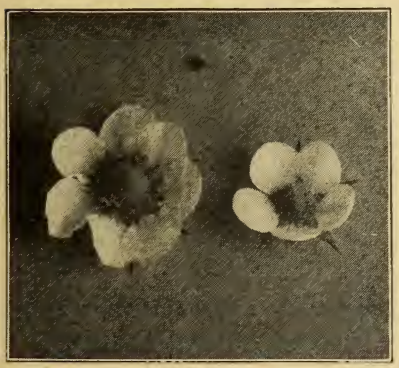

FIG. 9.—TYPES OF FLOWERS

Stamen-bearing flowers are necessary to fruit-production. Imperfect varieties must be accompanied by perfect. Left—perfect flower. Right—imperfect.

The strawberry plant is somewhat peculiar in that different varieties produce different kinds of flowers. Some varieties, such as Senator Dunlap, have flowers bearing both male and female organs, and are therefore capable of self-fertilization. Such varieties are known as perfect, staminate, or male varieties. The last two terms, however, are somewhat misleading, for the flower possesses both stamens and pistils, and is therefore not only a male but a female flower as well.

Other varieties, such as Warfield, have only the female organs present, and therefore cannot produce fruit without the presence of a stamen-bearing or perfect variety. Varieties having only the female sex organs are called imperfect, pistillate, or female varieties. We have no varieties of strawberries in which only the male organs, stamens, are present.

If an imperfect variety is to be grown, care must be taken to select a perfect variety to be planted with it so as to provide for pollination. The first consideration is simultaneous flowering. If a variety is to act as a pollinizer of another, both must be in flower at the same time. In fact, it is desirable to have a perfect variety in which the blooming period is longer than that of the imperfect, so that the ripe pollen may be available at all times. The perfect variety should also produce a large amount of pollen. Varieties differ materially in this respect, but unless conditions are very favorable, shy pollen-producers will not give good pollination of imperfect varieties. This

ability to produce abundant pollen is one of the chief factors in making Senator Dunlap such a good pollinizer.

Another requisite of a good pollinizer is its affinity for the imperfect variety. Comparatively little is known about the pollen affinities of different varieties, but experimental work has shown that such relationships do exist. This is shown by the fact that two perfect varieties of seemingly equal pollination possibilities may give very different results when used to fertilize the same imperfect variety. Some varieties seem to be quite cosmopolitan in their affinities, and if their other characteristics are favorable, these varieties should be choosen for this purpose. Of the varieties showing this cosmopolitan tendency none of those tried have exceeded Senator Dunlap in general qualifications as a good pollinizing variety.

It is commonly believed by growers that when perfect varieties are grown, it is not necessary to provide for cross fertilization. This is true, but investigation has shown that in most cases cross-fertilization gives better results than self-fertilization even with perfect varieties. For this reason it seems wise even when planting a perfect variety to use more than one variety.

What proportion of the pollinizing variety should be used? Doubtless much depends upon conditions. If the season is favorable for pollination or if bees are kept in the immediate vicinity, a smaller proportion of the pollinizer is necessary than if climatic conditions at flowering time were unfavorable, or pollen carriers scarce. One row of pollinizing plants to one of the variety to be pollinized is common, one to two is frequent, and one to three is sometimes used but is scarcely to be recommended.

What Varieties Are Best?

Frequently the question is asked: "What is the best variety of strawberry?" It is impossible to recommend any variety, or any two or three varieties, as the best, for no one variety does best under all conditions. It is equally true that certain varieties are more capable of adapting themselves to a greater range of conditions than are other varieties. As a result, these varieties are found growing over a wider range of territory and under more varying conditions than those less exacting in their requirements. It does not necessarily follow that such a variety will therefore be the best for any particular set of conditions; on the other hand, there is a greater probability that some less cosmopolitan variety will be more profitable if the grower only has the patience to determine which variety best meets his conditions.

Strawberries may be grouped into two classes, those which produce their fruit during the early summer, and the "everbearing" or those which produce an early crop and later on another crop continuing until cold weather prevents further production. The former class

is far the more important at the present time, but the everbearing varieties are becoming more popular as they are improved.

A study of varieties being grown in Wisconsin shows that regardless of varying soil conditions practically the same varieties are used in all parts of the state. This would indicate that these varieties are cosmopolitan and can be recommended as doing reasonably well under practically all conditions. A commercial grower should not be satisfied with average results. He should constantly be trying out a limited number of other varieties in comparison with the ones he is growing in an attempt to find, if possible, varieties which are better adapted to his conditions. It is some trouble and expense to run a trial plot for testing varieties, but it is quite likely to prove a paying investment.

The following varieties are suggested as likely to prove reasonably satisfactory while tests are being made to find if possible those better adapted to particular conditions: Dunlap, Warfield, Glen Mary, Pocomoke, Aroma, Gandy, and Sample. These are named approximately in the order of ripening.

Dunlap is the most extensively grown strawberry in Wisconsin, both in home and commercial plantations. It seems to be well adapted to a wide range of conditions. It is a heavy plant maker. Care should be exercised not to let it become too thick as production is reduced when this occurs.

Warfield is an imperfect variety, mostly grown as a companion berry of Dunlap. It is a hardy variety but under most conditions not as productive as Dunlap.

Glen Mary is partially imperfect and should be set with a pollinizer. It is a second early berry. A good producer but quite subject to spot.

Pocomoke. This variety is also called Gibson. It is a mid-season variety. It is hardy and productive, and produces large fruit which ships well.

Aroma. A large, high quality, attractive fruit which ships well. It is disease-resistant and productive. A good variety for producing a fancy product. Mid-season to late.

Gandy. A good late variety. Not productive except on heavy, moist soils.

Sample. One of the best late strawberries. Fruit large, attractive, and uniform. Ships only moderately well. It is imperfect, being commonly pollinated with Dunlap.

"Everbearing" Strawberries

The "everbearing" variety most popular in Wisconsin is Progressive. This variety is grown almost to the exclusion of other fall or everbearing varieties. Different varieties of the everbearers differ materially in the methods of handling. Owing to the popularity of Progressive, directions will be given for growing that variety.

The soil should be rich, even more fertile than for the June bearing varieties. It must contain a large amount of organic matter as an abundant moisture supply during July, August and early September is absolutely necessary if a good fall crop is to be secured.

Plant In Spring

The plants should be set in the spring as soon as soil conditions will permit. The plants should be about 24 inches apart in the row and the rows 3½ to 4 feet apart. These dimensions are for the matted row system, which most growers will find preferable.

Take Off Early Blossoms

For best results, the blossoms should be pinched off as soon as they appear until the early part of July. From that time on they may be left to produce fruit. Encourage the runners to root as readily as possible. A light mulch under the plants and frequent, shallow tillage between the rows are conducive to the largest production. Some system of artificial watering is very advantageous in growing the late crop, as frequently unless the best tillage and mulching is provided it is cut short by lack of moisture.

How Long?

Two crops are probably the maximum number to be taken from a plantation. Many growers take only the fall crop, as the spring crop is usually much lighter and the berries smaller. Most home growers, however, prefer to take a spring crop also. One of the reasons for this is that the everbearers ripen somewhat earlier than the June varieties. If the plantation is to be kept for a spring crop, it should be mulched during the winter as are the June varieties.

Liming Wisconsin Soils

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

DIGEST

Lime is added to soils to make it possible to grow clover, alfalfa and other legumes successfully on them. The lime has several uses for it takes a place in nitrification, helps to make phosphorus available to plants and combines with acids in plants that may be injurious.

Pages 3-5

Lime deficient soils are also usually deficient in available phosphorus. On farms where the manure supply is inadequate, limited quantities of phosphate fertilizer must be purchased to permit the maximum growth of legume crops. Pages 5-7

The lime needs of Wisconsin soils vary in the six important soil areas as shown on the map on page 7.

Lime has given profitable returns on sandy and silt loam soils in all parts of Wisconsin. The marsh soils of central and northern Wisconsin respond to lime, while those in southern Wisconsin do not need lime.

Pages 7-11

The portable limestone grinding machine is a success. It can operate successfully only in communities that are well supplied with quarries containing high quality limestone. Local grinding of lime in most communities reduces the long expensive wagon haul and makes it possible for farmers to haul the lime at their convenience.

Pages 11-16

The principal kinds of agricultural lime available to Wisconsin farmers are: Pulverized limestone, marl, paper mill waste, mine tailings, waste lime from sugar-beet factories, air slacked lime and burned lime or quicklime. Pages 17-20

Any form of lime should be applied previous to the crop which gives the greatest response to lime. Lime may be spread by hand with a shovel, with special lime sowers, or with a manure spreader. The end-gate type of lime spreader is best for spreading all forms of lime.

Pages 20-23

Liming for soil improvement should always be supplemented by fertilizing, either with barnyard manure or commercial fertilizer.

Page 24

Unleached wood ashes contain 50 per cent lime in addition to 5 per cent of potash. They may be applied at the rate of 2 tons per acre.

Page 24

Liming Wisconsin Soils

A. R. Whitson, Griffith Richards and H. W. Ullsperger

LIME IS NEEDED on 75 per cent of the tillable land in Wisconsin in order to grow the best crops of clover, alfalfa and other legumes. It is well known that the growing of leguminous plants, such as clover and alfalfa, is one of the most important principles in maintaining the fertility of the soil. Wisconsin farmers should apply lime to their land in order to increase their crop yields. Fortunately, many sections of Wisconsin have inexhaustible deposits of limestone, while in the sandy sections where no lime is found, marl beds can be dredged to supply the lime.

Uses of Lime in the Soil—Lime has several uses in the soil. It takes part in the nitrification by which the nitrogen of organic matter is converted into a form which can be absorbed by plants. It combines with phosphorus and assists in making that element available to plants. It combines with acids formed in plants, neutralizing them so they will not be injurious to the plant.

Fig. 1.—A SPLENDID ALFALFA FIELD ON SANDY SOIL

Four tons of limestone and twelve loads of manure per acre helped to produce this wonderful alfalfa crop on a rather poor sandy loam soil that would not grow red clover before these fertilizer treatments were made. This field is located at the United States Government Indian School at Tomah.

Forms of Lime in Soil—Lime or calcium exists in the soil in several combinations with other elements. It exists in silicates or minerals in granitic rocks; in carbonates which constitute limestones; in organic matter, as well as in such salts as sulphates, chlorides, and nitrates

which exist, however, in very small amounts in all except alkali soils. The total amount in soils in all these forms varies greatly. Some Wisconsin soils have 30,000 to 40,000 pounds of calcium, the chief element in lime, while others have less than a thousand. The lime in some forms is more available than in others. Lime in carbonate form is easily used and that in some kinds of silicates also may be used.

Relation of Lime to Acidity—Lime is one of the class of substances called bases by the chemist. Bases combine with acids and form salts, a process which is called neutralizing the acidity. Acidity of the soil is caused by insufficient lime or other base to neutralize all the acid portion of the soil. But there may be considerable available lime in the soil even though there is not enough to neutralize all the acidity. On the other hand, soils with little or no acidity also may have very little available lime. It is therefore impossible to determine the amount of available lime by determining the degree of acidity. Some soils are very deficient in available lime even though they are only slightly acid, and other soils are well supplied with available lime in spite of considerable acidity.

The soils of northern Wisconsin have in the virgin state a good supply of available lime. This is shown by the excellent growth made by all crops including clover although practically all the soils are distinctly acid. After they have been cropped a number of years so much available lime has been used up that more is needed.

Since acidity of soils tends to keep the lime from being available, a knowledge of the degree of acidity in the soil helps in determining whether it needs lime or not. But at present the only certain method is actual field trial; and such trials are the best guide to the amount of lime which should be used.

A Simple Test of the Need for Lime—A simple test is made as follows: Slake a bushel of quick lime with water. When it is in a dry powdered condition spread it and work it into a strip of ground a rod wide and four rods long. This should be done after plowing. In place of the bushel of quick lime, two bushels of air slaked lime or 150 pounds of ground limestone may be used. The strip should be in a field where clover does not do as well as it should. The lime can be applied when preparing the field for corn the year before it will be seeded down or the same year it is being seeded although better results on clover or alfalfa are secured when lime is applied a year before the clover or alfalfa is sown.

Lime for Legumes

Legumes such as clover and alfalfa maintain the nitrogen in the soil. They use the nitrogen of the air for their growth through the work of the certain kinds of bacteria or germs which penetrate the smaller hair-like roots of these plants and cause abnormal swellings called nodules. Within

these nodules the nitrogen from the soil air is "fixed" in some way, that is, the nitrogen gas is built up into fertilizing materials which the legumes can use in their growth. Under proper conditions, therefore, these plants can get their nitrogen from the air and grow on soils which do not contain nitrogen in the form of nitrates or ammonium compounds, as is necessary for the growth of other crops.

The bacteria which form nodules on medium red clover, alfalfa, and sweet clover, require more lime than the bacteria which develop nodules on the roots of some other legumes such as cowpeas, lupines, and serradella.

Medium red clover, mammoth clover, and alfalfa can fix more nitrogen in a season than can those legumes which can grow on soils deficient in lime. Furthermore, they are better forage crops than most, if not all legumes which will grow on lime deficient soils because they can be made into hay more readily. Alfalfa yields larger amounts of valuable feed than legumes which thrive on lime deficient soils. It is, therefore, desirable to lime the soils when necessary and grow clover and alfalfa, rather than to raise legume crops that will tolerate lime deficient soils. Nevertheless, where the cost of lime is too great on account of distance from an available supply, or for other reasons, these second rate legumes should be used to maintain the nitrogen supply of the soil.

Legumes Need Phosphates as Well as Lime

Legumes, like all other plants, require mineral elements such as phosphorus and potassium as well as lime. Therefore, even legumes which are able to obtain their nitrogen from the air must depend on the supply of these mineral elements present in the soil. Their growth will thus be limited unless an abundant supply of these elements is present in the soil in an available form. Well-rotted barnyard manure is an excellent source of these mineral elements and the heaviest crops of clover and alfalfa can be grown by using it as a fertilizer. However, in using barnyard manure for leguminous crops these plants are being fed nitrogen and are not forced to gather it from the air. Unless the entire farm is already in a high state of fertility and a sufficient supply of manure is produced to fertilize every field abundantly, it is better to purchase at least limited quantities of phosphorus and lime needed to permit the maximum growth of legumes, especially of alfalfa. The manure may then be applied to land on which other crops such as corn and grain are grown so that the nitrogen in the manure will be used to the best advantage.

Relation of Lime to Available Phosphorus

Phosphorus is ordinarily present in soils in very limited amounts, and since it is sold in practically every product which leaves the farm

it is in greatest danger of serious reduction. The bones of animals sold take it off the farm in concentrated form. On a large fraction of the farms of the state the supply of phosphorus is too small to permit the largest yields of crops.

Even though practically all the crops grown on the farm are fed and the manure returned, there is still a considerable loss of phosphorus from the farm in the bones of animals or milk sold. Only the purchase of considerable bran, oil meal, or other feed high in protein or of phosphorus fertilizers will replace this element.

Fig. 2—MOST ACID SOILS RESPOND TO PHOSPHATE FERTILIZERS

On this acid prairie soil, the addition of phosphate produced a larger yield of corn and ears of better quality. Corn from the phosphate plot on right. On such land, corn and oats need phosphate especially, while clover or alfalfa require lime in addition to phosphate.

There appears to be a close connection between the amount of lime in the soil and the availability of phosphorus. In general, acid soils low in lime are also low in available phosphorus and respond to a phosphate fertilizer. Black prairie soils which have long been cropped are very deficient in available phosphorus (Fig. 2), although they still have a good supply of nitrogen. Marsh soils low in lime need phosphorus as well as potassium, while those high in lime usually need potassium only, at least during the first few years of cropping.

How Much Lime to Use

The sketch map Fig. 3 shows the most important soil areas in the state. The lime requirements of each can be fairly well stated.

No. 1—Unglaciated Limestone Area.—Long leaching and cropping of these soils has removed much of the available lime, especially on the

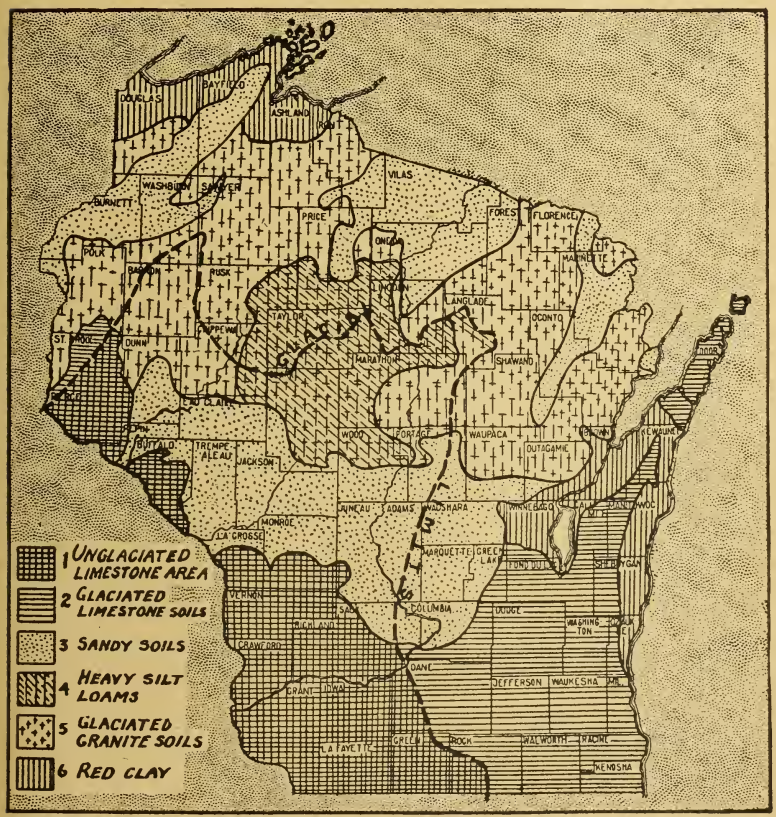

Fig. 3.—THE SIX SOIL AREAS IN WISCONSIN HAVE DIFFERENT LIME REQUIREMENTS

Lime is required in amounts varying from 2 to 4 tons per acre for the alfalfa crop on areas 1, 3, 4 and 5. Lime is generally not required on the heavy red clay soils even for the alfalfa crop.

higher portions; so in that region the use of two to three tons of ground limestone for alfalfa per acre when first seeded and one to two tons at each later seeding is quite necessary on the upper slopes and hill tops. An application of one to two tons every three to five years

will probably be profitable on the other staple crops including clover. The soils of the lower slopes and valleys of this region have in many cases received considerable lime carried down by the water seeping underground from the higher hillsides; so that lime is less necessary and will be required probably only for alfalfa.

No. 2.—Glaciated Limestone Soils—The soils of this region were originally formed by the glacial ice grinding up some of the limestone rock and mixing it with the surface soil previously there. Most of the soils of this region, therefore, have an abundance of available lime in their subsoils. Nevertheless, the upper slopes and hill tops have often been robbed of their lime by leaching and the growing of crops to such an extent that an application of ground limestone now, at least for alfalfa, is necessary to get the best results. The marsh soils of this region are well supplied with lime brought down by water seeping into them from surrounding land containing lime.

No. 3—Sandy Soils—The soils shown as No. 3 on the map are practically always low in available lime. The only exception to this occurs in portions of Waushara, Marquette, and Columbia counties where the ice flowed across from a region of limestone rock onto a region of sandstone and carried with it more or less ground limestone. East of the moraine in these counties some fields are to be found in the soil of which pebbles and grains of limestone brought by the ice occur and such fields are therefore well supplied with lime. Except in these limited cases the sandy soils of the area numbered 3 require one to two tons of ground limestone or marl per acre every four to six years for staple crops, including corn, rye and clover.

When seeding down to alfalfa a heavier application should be made and probably 2½ to 3 tons of ground limestone or marl is the most profitable rate for the first application. From 1½ to 2 tons are needed whenever the same field is reseeded to alfalfa thereafter.

The marsh soils of the sandy area are low in lime and while this has not been a disadvantage in many cases so far, it is well to make a trial as suggested on page 4. After such land has been broken and cropped a few years it is quite probable that lime at the rate suggested for the upland will be found profitable. This applies especially to marsh lands lying west of the Wisconsin river.

No. 4—Heavy Silt Loams—While these soils are very acid they still have a large supply of available lime, making further application on new land unnecessary in order to secure good yields of most of our staple crops. Experiments at the Marshfield Experiment Station indicate that a light application of 1½ to 2 tons per acre is profitable for the staple crops including oats, corn, and clover on all land which has been under crop from 15 to 25 years. For alfalfa in this section three tons per acre should be applied when first seeded and 1½ to 2 tons whenever the same land is reseeded to this crop. Good drainage is just

as necessary as lime for alfalfa on this soil. The marsh soils of this region are lower in lime than the upland and will be benefited by liming in most cases.

No. 5.—Glaciated Granite Soils—These soils are similar to the heavy silt loams in their lime requirements and the same rates of application should be used. The marsh soils of this area are also similar to those in the area of heavy silt loams.

No. 6.—Red Clay—This soil was deposited as sediment in a former extension of the Great Lakes during the glacial period and is well supplied with lime. Only on a few hill tops where crops have been grown a considerable number of years is the use of lime necessary even for alfalfa but good drainage is always essential for that crop.

What Liming Does

Space will not permit the recording of the results of all field trials where lime has been used. The beneficial effect of lime on acid soils is illustrated by the results of only a few field tests which follow. At Ellis Junction, Marinette county, two plots of alfalfa were seeded in the same field of acid sandy soil without a nurse crop. One plot received an application of air-slaked lime at the rate of one ton per acre. The other plot received no lime. Both were manured at the rate of 6 loads per acre and inoculated. The following year 2,080 pounds (from two cuttings) of alfalfa hay were cut per acre on the limed plot, and only 1,340 pounds per acre on the unlimed. This shows a gain of 55.2 per cent in favor of lime.

In another field at the same place two other plots were seeded to alfalfa the same year. One plot was limed and the other received no lime. Two cuttings were made on each plot. Exactly 2,780 pounds of hay per acre were taken off the limed plot and 1,940 pounds per acre from the unlimed. This represents a 43.3 per cent increase due to lime. The quality of the hay was also improved as about 20 per cent of the hay cut on the unlimed plot was June grass while the crop on the limed plot was good alfalfa hay.

At the Sparta substation two plots of acid sandy soil were seeded to mammoth clover without a nurse crop. One plot was treated with ground limestone at the rate of one ton per acre before seeding, and the other received no lime. The following year 1,906 pounds of clover hay were cut per acre from the limed plot while the crop on the unlimed plot was a failure.

Mammoth clover growing on acid sandy soil treated with lime and manure gave a yield of 5,063 pounds of hay per acre while on land treated with manure alone the yield was 3,566 pounds. This shows a gain of nearly 42 per cent in favor of lime.

Soybeans on limed soil produced 6.96 tons of green crop per acre.

Only 2.27 tons were cut per acre where no lime was applied. In this case the lime more than doubled the yield. The following year the yields on limed plots were 66.6 and 77.8 per cent greater than on unlimed soil.

When three tons of pulverized limestone were applied to an acre of silt loam soil on a farm near Barron, Wisconsin, the barley crop was increased from 35 to 50 bushels per acre. This is an increase of over 42 per cent of grain. Additional returns for the limestone were also received due to the increase in the alfalfa crop that followed.

On the Green county farm at Monroe, Wisconsin, a 4 ton application of pulverized limestone resulted in a yield of 16,200 pounds of green alfalfa on an acre, while the unlimed area produced only 11,200 pounds of green alfalfa. This is a 30.8 per cent increase due to an application of limestone.

Liming Materials That May Be Used

Since there are so many different "limes" upon the market that may be used for soil improvement, the farmer naturally becomes puzzled as to which is the best form to use. The action of all these limes in the soil is practically the same; the only difference there may be is in their quickness of action. Burnt lime, for example, has a quicker action upon the soil than ground limestone because of its caustic properties; while marl when evenly spread produces quicker results than ground limestone because it is a much more friable and finely divided material.

Just what choice is to be made depends largely upon the initial cost, freight, distance to be hauled, time and labor required to get it spread upon the field, and the kind of soil. Concentration and fineness should, in a large measure, determine the real value of any form of agricultural lime. Too high a water content will make even ground limestone a very expensive material. It is very important that the farmer know the water content of any form of lime before buying, so that he may be able to get the greatest amount of carbonates for his money.

Pulverized Limestone Used

Pulverized limestone is the main form of lime now used in this state. Fortunately Wisconsin is supplied with unlimited quantities of high quality limestone suitable to be crushed and pulverized for agricultural use (See map on page 13.) The quarries are fairly evenly distributed over southern and eastern Wisconsin, but in the northwestern part of the state they are rather scattered and not very numerous. The sandy central portion of the state as well as most of the northern part has practically no limestone deposits of value.

Practically all of the limestone in Wisconsin is known as "dolomite." It contains a mixture of calcium and magnesium carbonates. The magnesium carbonates often make up 45 per cent of the mixture. It was

formerly thought that the magnesium was injurious to plant growth, but recent experiments and field trials show that the dolomitic carbonates have no detrimental effect.

Fig. 4.—A LOCAL SOURCE OF LIME

There are hundreds of limestone quarries in Wisconsin that can supply the stone for the portable limestone grinding machines. In many quarries the limestone is loosely laid in thinner layers than is the case in this quarry. The cost of quarrying the stone is much less where it is found in thin layers.

Dolomitic limestones are just as valuable for farming as limestone containing nothing but calcium carbonates. However, not all the limestone deposits in the state are suitable for agricultural use. A limestone should have at least 90 per cent calcium and magnesium carbonates to warrant its use. Limestone often contains rather large amounts of flint and sand as impurities. The only accurate way to find out the true value of a limestone is by a chemical analysis. Samples carefully taken so as to represent the quarries from which they come will be analyzed free for the citizens of Wisconsin by the Soils Department, College of Agriculture.

Portable Grinding Machine Succeeds

Fifteen years ago many people questioned the success of the small portable lime grinding machines. They did not believe that machines could be built strong enough to stand the strain of rock grinding. The experience of the operators of these machines has now proven that it is a practical method of preparing agricultural limestone. Accurate figures as to the amount of limestone pulverized by these machines in Wisconsin are not available but it has been estimated that up-to-date they have produced about 50,000 tons. If all this limestone was to be loaded on cars holding 50 tons each, it would make a long train of 1000 freight cars. Only a start has been made, however, for if all of this 50,000 tons were to be applied to all the land surface in a regular township there would not be enough to make even a two ton application to each acre. There should be many more machines operating in Wisconsin right now for there is much work for them to do.

The Portable Grinder Eliminates Long Haul—Farmers have questioned the wisdom and economy of hauling limestone more than three or four miles over steep hills and rough roads from their nearest railroad station to the farm. No doubt, many farmers were justified in not using lime when the farm was located more than four miles from the railway station. Fortunately, thousands of farmers in Wisconsin have limestone quarries within four miles or even closer to their farms. These farmers are the ones who receive the greatest service from the lime grinder. They can haul their lime from the quarry when their time permits and when the roads are best. They need not worry about demurrage charges on cars that have not been unloaded by a specified time. Agricultural limestone is really worth more to farmers when piled up for them in a near-by quarry than it is in the freight car at the railway station.

Fig. 5.—A LIME GRINDER IN ACTION

The pioneer farmers in Green Lake County built their fences of limestone. Today the limestone in these old fences is being pulverized and applied to the fields to make the conditions right for the alfalfa crop.

Field for the Lime Grinder—The portable lime grinding machine can be of greatest service to farmers only in communities that are fortunate enough to have quarries containing high analysis limestone; and these quarries should be evenly distributed over the area, so farmers will not

be obliged to haul their limestone more than four miles. The lime grinding in the past has been done largely in Rock, Green, Iowa, Green Lake, La Fayette, Dane, Grant and Walworth counties. These areas have a rather wide and even distribution of good limestone quarries that are also very accessible. To be sure the portable lime grinder will

Fig. 6.—LOCATION OF THE MAIN SOURCES OF LIME IN WISCONSIN

The main source of lime in Wisconsin is pulverized limestone which is produced by commercial companies and by portable lime grinding machines. The marl deposits are proving to be a valuable source of lime in areas not supplied with limestone.

operate in Door, Outagamie, Columbia, Sauk, Crawford, Vernon, Monroe, La Crosse and Buffalo counties as well as other counties where good limestone quarries are not so numerous and also in spite of the fact that many of them are rather inaccessible.

Limestone Should Be Tested—A lime grinder should not operate in a

quarry until the limestone has been analyzed and found to be of high quality . When a farmer pays out hard earned cash for limestone and spends much time and labor applying it to his fields he certainly should know that he is buying high analysis limestone. Therefore before any limestone quarry is operated one or more samples should be taken from the quarry and mailed to the Soils Department, College of Agriculture, Madison, Wisconsin, for analysis.

How to Collect a Sample for Analysis—In taking samples of limestone to examine it for its fitness for agricultural use, the following points should be observed:

(1) If the bed or quarry shows strata, or layers of different degrees of hardness, or layers containing different amounts of chert or flint, then

Fig. 7.—A LOCAL SUPPLY OF LIMESTONE

A. H. Douglas, Brodhead, Wisconsin, pulverized these piles of limestone with his portable lime grinder for individual farmers in Green County. The machine was equipped with a weigher taken from a grain separator and the limestone in these piles was actually weighed for each farmer as it was being produced.

a separate sample should be taken of each stratum or bed. Often there is a two or three foot layer which is much softer than the others, and relatively free from chert or flint. This can be ground with much less expense, provided it has a sufficient degree of purity.

(2) In collecting each sample take a large number of small chips an inch or so in diameter from different places in the bed or stratum so as to get an average sample. Take enough to make a quart.

(3) The sample should be accompanied by a statement describing the bed or exposure, giving its depth, width, and the lay of the land, which

would affect the readiness with which the rock could be gotten out, and the mill placed for grinding.

County Lime Grinding Successful—The county agent knows the need for lime and can become an active director of the lime grinding work. Splendid examples of this kind of work have been done in Rock, Green, Iowa, Green Lake and a few other counties. The county agent calls meetings where farmers sign contracts that keep the lime grinding machine busy. He prefers to have the machine operated by a man who is making a business of grinding limestone. He knows that there are a great many machines purchased by groups of farmers that stand idle part of the time; and that a man who grinds lime for a living will get more lime ground than a group of farmers who generally have about all the work they can do to keep things running on their farms.

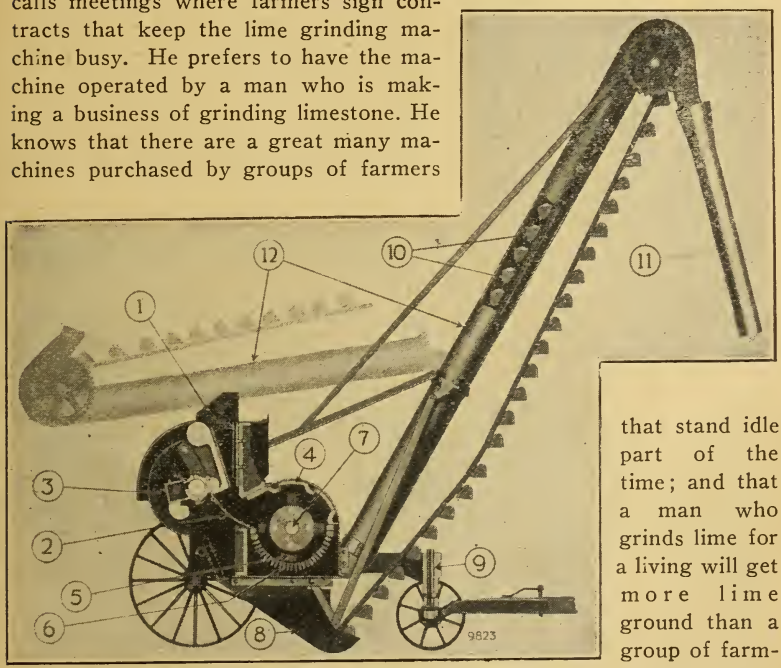

Fig. 8.—A COMBINATION CRUSHER AND PULVERIZER

This shows the jaw principle for crushing and the swing hammer principle for pulverizing. This combination is very desirable for hard, thick-bedded limestone. A small pulverizer alone mounted on a truck is convenient for farm or community pulverizing when the limestone is thin bedded.

No doubt a number of cooperatively and individually owned machines will produce lime for the owners of farms as well as for a few of the neighbors. All of these methods of machine ownership and operation are going to help Wisconsin farmers get lime on their fields, but progress of a lime program in any county will be slow without a county agent to direct it, and without some hard-working, efficient man who makes a business of grinding lime for farmers at a definite price per ton.

Making Lime Grinding a Business—It is essential to purchase a ma-

chine with not less than 30 tons capacity for a ten hour working day. Machines equipped with both crusher and pulverizer are giving satisfaction generally.

To operate these machines at full capacity it is necessary to have plenty of power. Machines that have a capacity of 30 tons for a ten hour day give best results when operated with a 15-30 gas tractor. It is an advantage to have surplus power. The man who operates a lime grinder should understand machinery for his financial success depends a great deal on keeping the machinery operating continuously. It will also depend on his ability to place his machinery so that the limestone can be brought to the machine most cheaply. The machine must be pulverizing limestone all the time that it is in operation in order to produce tonnage enough to make the enterprise a financial success. A platform should be built up nearly level with the mouth of the pulverizer, on which the rock can be dumped and from which it can be easily fed to the machine. Ordinarily a crew of four men is used to operate to the best advantage, but the number required depends on the ease or difficulty of getting the rock out of the quarry and to the machine.

Fig. 9—ROCK COUNTY GRINDS LIME

Many piles similar to this 200 ton pile of pulverized limestone may be seen in Rock county. George K. Nelson operates this machine which has pulverized 5,000 tons of limestone for Rock county farmers during the past three years.

Cost of Lime Grinding—Figures as to the actual cost of lime grinding are almost impossible to get because of the wide variety of conditions. Some quarries can be opened up easily and cheaply while others require considerable stripping away of earth. Some limestone is soft and more brittle than other stone. The soft brittle stone will generally go through the machine much more rapidly than hard stone. In some quarries the stone is found in thick layers and it can easily be seen that much labor is required to get the stone loose as well as to break it up small enough for the machine. Men operating machines in quarries of this kind must get more per ton for their finished limestone than is necessary in quarries where the stone is loose, in thin layers, and easy to take out and break. At present, Wisconsin farmers are paying all the way from $2 to $3 per ton depend-

ing on local conditions. Any farmer ought to be willing to pay at least as much for limestone pulverized locally as he would have to pay for "shipped in" limestone of equal quality. Some farmers have made arrangements to haul their limestone directly from the machine as it is produced and thus the charges for grinding can be reduced a little because it is not necessary to shovel the limestone away from the machine. It also saves the farmer the labor of handling it once. The labor cost is one of the big factors in the entire liming proposition and anything that will reduce it should certainly be done.

In many communities the farmer furnishes the stone free to his neighbors but the usual charge is 10 cents per ton for the raw stone. No doubt, the owner of the quarry is entitled to this small charge because farmers are driving across his land and there may be some wear and tear on gates.

Use of Mine Tailings

Tailings are a by-product of the lead and zinc mines in southwestern Wisconsin. Near some of the mines are piles containing thousands of tons of these tailings. In the past, this material was used largely for road building but it may be used as a source of agricultural lime. The lime content may vary from 50 to 90 per cent, so it is advisable to have samples of tailings analyzed in order to determine their true value before use.

The degree of fineness of the tailings varies at different mines, but as a rule the material is rather coarse. It is advisable to use from 50 per cent to 75 per cent more tailings than would be needed of finely pulverized limestone. They should, if possible, be applied a year or two in advance of the time of seeding the alfalfa crop. When used in this way, the coarse particles will have more time to react with the soil. Farmers living near these mine tailing piles will do well to haul them on their fields in order to get the land in condition to grow alfalfa. A few farmers have already established splendid alfalfa fields with the aid of tailings, but their use can become much more general.

Tailings may contain small amounts of lead and zinc compounds which might prove poisonous to plants. Farmers who plan to apply tailings to their fields in the future should avoid the use of tailings from the parts of the piles that contain much lead and zinc. The number of farmers who report unfavorable results from the use of tailings is very small as compared with the great number that have had good results. More field experimental work needs to be done to determine more definitely the true value of tailings for soil improvement work.

Marl Found in State

Marl is a form of carbonate of lime that has been deposited from water. Pure marl has a chalky white color but ordinarily marl is blue

gray, or grayish in color, intermixed with white or gray colored remains of snail shells, clam shells, or other shell fish. Part of this marl comes from the remains of these shell fish, other parts come from lime washed out of the soil through drainage waters and secreted by plants. This lime is carried to lakes and rivers and creeks and deposited there.

Blue clay often resembles marl but if hydrochloric acid is added to marl it will bubble or effervesce while with clay no action will be seen. The purity of the sample is determined by the amount of marl that disappears in the acid test. Such impurities as sand or clay will remain. Pure marl will disappear almost entirely if sufficient acid is added.

Most of the marl deposits in the state are covered with water, peat,

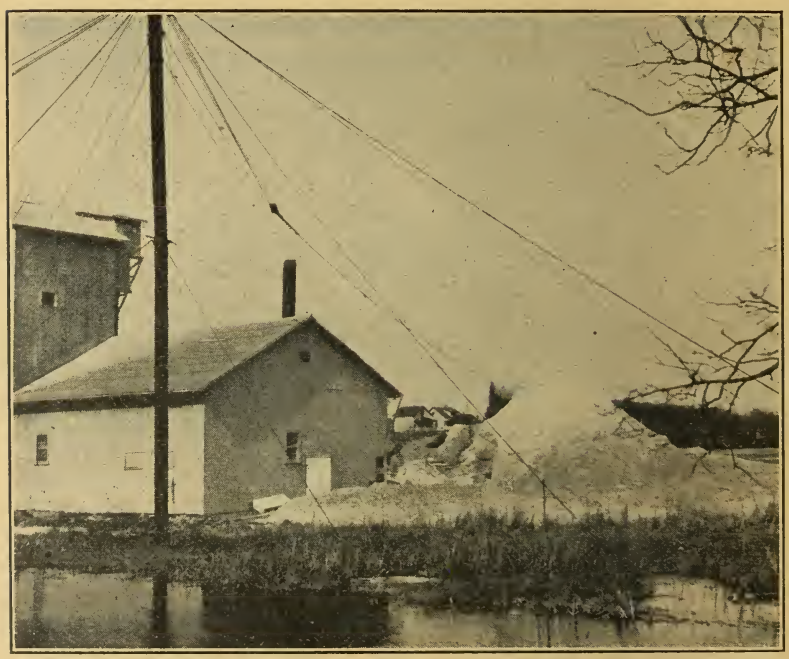

Fig. 10—A MARL DRYING AND PULVERIZING PLANT

Wisconsin has many lakes from which marl may be dredged. Thousands of tons of marl have been dredged out of lake bottoms this year. It is put in big piles on the shores of lakes and after it has air-dried, farmers haul it to their farms. This, however, is the only marl drying and pulverizing plant in operation at present in Wisconsin.

or muck soils which means that marl is saturated with water. This fact, together with the difficulty of getting the marl has limited its use up to the present.

Value of Marl—Pure marl is just as valuable as the best limestone on the market, providing both are equally dry. Marl has been used in agriculture both here and in Europe with very good results. Farmers near marl beds have used small quantities on their legume crops with good success; and its use has passed beyond the experimental stage.

Marl Excavators Obtainable—Small portable cableway marl excavators have been invented recently to dredge or move marl to places where it can be air dried, loaded on wagons, and hauled away to farmers. This excavator costs between $800 to $900 set up. Power in the form of an ordinary tractor or 12 to 15 horsepower stationary engine is not included and must be supplied extra by the purchaser.

The actual cost of getting out a yard of marl is not over 50 cents and is usually less. Adding to this the cost of marl, overhead, and other charges plus profit, means that the total cost per cubic yard should usually not be over a dollar.

Before buying and installing a marl dredge these points should be considered:

1. The quality of the marl.
2. The demand for marl. Get signed requests. Does soil need it?
3. Supply of marl available or obtainable in the marl bed.
4. Efficiency of operator.
5. Reasonable charges.
6. Convenient placing of marl for hauling.

A number of these marl excavators will be used in central Wisconsin in the near future. Further data can be secured from the Soils Department, College of Agriculture, Madison, Wisconsin.

Shell Dust Useful—Small amounts of ground shells may be had from button factories along the Mississippi River. After the clam shells have been bored for "blanks" they are run through a pulverizing machine. Dry shell dust will contain about 95 per cent lime carbonate. A very limited amount of this material is available; probably only a few hundred tons are produced yearly.

Burned Lime or Quick Lime—"Burned lime" is ordinary lime prepared by burning lumps of limestone to a red heat in kilns. The terms "quicklime," "caustic lime" "lump lime," and "builder's lime" are also given to it. This is the most concentrated and caustic form in which lime is supplied. One ton of burned lime is equal to two tons of pulverized limestone; hence this form of lime may be used to advantage by a farmer who lives a long distance from a railroad for the hauling expense will be reduced one-half. It must be air or water slaked to a dry, powdered condition before spreading.

Air Slacked Lime—This is formed when 'burned lime" is exposed to air and moisture for some time. The carbon dioxide from the air is

absorbed and converted into carbonate of lime. It is finely divided and may be applied directly to the land. It has the same composition and value as ground limestone. Sometimes large quantities of air slacked lime, known as "damaged lime" or "refuse lime" may be bought at a very low figure, or for the mere cost of loading and freight, from lime dealers, kilns, or users of large quantities of burned lime. Farmers living near have a very cheap source of lime.

Lime from Beet-Sugar Factories—Two forms of lime may be had from beet-sugar factories. One is refuse lime from the kilns and slacking tanks, and the other is lime carbonates from the filter presses. These materials are thrown into dumps where, on exposure to the air, they pass over into a material consisting of air and water-slacked lime. This may contain from 30 to 60 per cent water so it is impracticable to pay freight on it any great distance unless it is at least partially dried. Farmers living near beet-sugar factories find this a very cheap source of lime. It can be spread only by hand or with a manure spreader.

The lime carbonate from the presses may be applied to soils after it has been allowed to air-dry in the dumps. It contains in addition to lime carbonate, traces of nitrogen, phosphorus, and potassium absorbed from the beet juices. When dry this material is a very pure form of lime.

Waste Lime from Paper Mills—Central Wisconsin has a number of paper mills that use pure burnt lime in their purifying processes. This lime, after use, is dumped in their yards. A number of Wisconsin farmers have used this lime with good results. This grade of lime can be recommended safely for farms near these paper mills. There are mills at Mosinee, Stevens Point, Nekoosa, Kaukauna, Peshtigo and other places. Each of these mills has a large supply of waste lime on hand. Some of them have given a permit to farmers to haul the lime away without cost and many are using this lime at present.

When and How to Apply Lime

Any form of lime should be applied previous to the crops which give the greatest response to lime. In Wisconsin, lime is used mainly to prepare the soil for the clover and alfalfa crops. Whenever possible it may be applied a year in advance of the time of seeding these crops. In order to prevent losses from leaching, it is advisable to apply it to plowed land and mix it with the soil by harrowing. Fall, winter or spring applications may be made on clay soils, but on light sandy soils spring applications are preferable so as to prevent leaching.

Spreading Lime From the Wagon.—Any form of lime which is damp enough to prevent blowing can be spread very well with a shovel directly from the wagon. A little skill in handling the shovel will enable the operator to spread it both quickly and evenly.

Fertilizer Distributers and Lime Spreaders.—Any form of lime that is dry and pulverized finely enough to pass a one-fourth inch screen can be applied very evenly with a two-wheeled, drill type fertilizer and lime distributor. The machine should be equipped with two agitators. These are necessary to work the material down to the bottom of the hopper so it will feed through evenly and constantly. These machines spread the material very evenly and do fairly good work even when it is quite windy. They will not handle satisfactorily pulverized limestone that has been piled in the field and become wet.

The best machine to use for handling wet pulverized limestone is

Fig.11.—A DRILL TYPE LIME AND FERTILIZER SOWER

This type of machine will give very even distribution of dry pulverized limestone of all kinds. There is some limestone in Wisconsin, however, that will not feed down and through these machines when it becomes wet.

an end-gate spreader that may be attached to the rear of a wagon box. This machine requires one man to shovel the lime into the hopper from the wagon box and another to drive the team. This machine will not give even distribution of dry fine material on a windy day. With this machine a farmer can equip one rear wheel of two or more wagons with driving sprockets and the machine is light enough so that it may be transferred from one wagon to another. This method saves handling the lime, for it may be hauled directly from the railroad and spread on the land at once.

Spreading Lime by Using a Manure Spreader.—Sometimes a manure spreader may be used to spread lime. The spreader is set at its lowest gear, a few inches of fine manure spread over the bottom of the box to hold the lime in, and the lime distributed evenly on top of this thin layer of manure. If three tons of refuse lime are to be applied per acre, and the machine is set at four loads per acre, as on lowest gear, then each load must contain at least 1500 pounds of lime.

Hints on Applying Quicklime.—If quicklime is to be used, it can be hauled to the field and placed in little piles on the plowed land. Fifty

Fig. 12.—A GOOD LIME AND FERTILIZER SOWER

The end-gate lime and fertilizer sower will distribute wet limestone satisfactorily. The limestone is spread over a strip 16 feet wide. This type of machine saves one handling of the limestone, but a boy is needed to drive the team while a man shovels the limestone from the wagon box into the machine.

pounds in each pile and the piles placed two rods apart each way, will give an application of one ton per acre. This lime may be slacked either by pouring a pailful of water on each pile or covering each with moist soil. As soon as the lime becomes slaked, the finely divided material should be carefully spread, the contents of each pile to be spread over four square rods. When this is done, the field is harrowed to work the lime well into the soil where it must be to do its work in correcting the acidity.

Under no consideration should quicklime ever be applied as a top dressing on young clover or alfalfa, for the caustic properties of this form of lime will kill the young plants.

Applying Lime as a Top Dressing.—Applying lime as a top dressing on young clover or alfalfa growing on sandy soils may prove very satisfactory if kiln-dried marl or finely ground limestone are used, though better results are obtained by liming the plowed field before seeding. The openness of a sandy soil enables the fine lime particles to work their way down into the soil. Top dressings on heavy clay loam or silt loam have not given very satisfactory results, for these soils will not permit the easy entrance of the lime particles as in case of sand.

Sometimes, however, after harvest or in the fall, a farmer wishes to lime his spring seeding of clover or alfalfa on clay loam, for example, in order to increase the yield of hay the next year, if possible. In such a case, partially air-slacked or water-slacked lime applied at the rate of a ton or a ton and a half per acre early next spring before the frost is out, may be beneficial. Such an application should never be made after the young plants have started their new year's growth, because there may be sufficient caustic lime in the material applied to kill them. A sandy soil may be treated in the same way.

Mixing Lime with Manure.—It is not good practice to mix burnt lime, incompletely air-slaked or water-slaked lime with manure. The caustic properties of these forms of lime give them the ability to hasten the destruction of organic matter, hence mixing them with manure will cause excessive losses of the fertility, especially of the nitrogen contained in the manure. Ground limestone, marl, and ground shells, on the other hand, may be mixed and applied with the manure with no appreciable harm.

Most farmers apply manure on land to be cropped to corn and potatoes. Where a manure spreader is used, it is convenient to apply ground limestone or marl at the same time by spreading it evenly on top of the spreader load. If eight spreader loads of manure are applied per acre, and two tons of pulverized limestone are to be added, then on each load there must be spread 500 pounds of limestone. It is not considered good practice, however, to lime land to be cropped to potatoes, for lime favors the development of scab.

Since lime is applied to the soil to benefit the growth of certain legumes, the effect of the lime applied in this way is to be looked for in the clover and alfalfa following the corn crop. If it is not the intention of the farmer to follow the corn immediately with clover or alfalfa, (grain may be the nurse crop), it would be better to withhold the lime application until directly before seeding the clover or alfalfa.

Applying limestone or marl with manure on corn land before seeding to clover or alfalfa is not to be recommended on sandy soil, because considerable lime may leach out of this soil and become lost before the clover crop, which is to receive the benefit of the liming, is seeded.

Handling Lime.—Handling burnt lime, dry air-slaked lime, or kiln-dried marl may be very disagreeable on account of the dust inhaled. Wearing a moist sponge under the nose makes the dust less objection-

able. The dust collected in the sponge should be washed out now and then by rinsing it in a pail of water.

Ground limestone, marl, air-slaked lime, ground shells, and lime carbonate refuse do not change or lose any of their power to correct acidity on exposure to the weather. Burnt lime and water-slaked lime gradually change over into carbonate of lime, but this change does not lessen their value for neutralizing acidity in soils.

Lime Alone Cannot Restore Worn Out Land

A soil depleted of its original fertility by constant cropping and which will no longer produce crops at a profit without fertilization, is considered a 'worn out" soil. Such a soil may have lost its available lime and will then require lime as the first step in its improvement. Lime alone however, can never restore that soil to its original state of fertility. Usually nitrogen and phosphorus must also be added,—the nitrogen best through legumes, the phosphorus in some form of phosphate fertilizer.

It must be understood that lime is not a panacea for all soil ailments, as one is lead to believe in statements such as the following:

"We handle no other fertilizer, and after you use this (meaning lime) you will never buy any other."

Statements have even been made by those having lime to sell that the Wisconsin Experiment Station "has quit recommending commercial fertilizer to any one." This is far from the truth. For example, marsh soils are generally deficient in potassium, and only a potassium fertilizer or manure can supply this necessary element. Again, it is recommended that soils which show by field tests a lack of phosphorus, should be treated with phosphorus fertilizers.

The Value of Ashes

Unleached wood ashes, which usually contain about 5 per cent potassium in form of carbonates, 50 per cent carbonate of lime and about one-half of one per cent of phosphorus, are especially valuable in that they not only act as neutralizers, but as fertilizers as well. Two tons per acre would add to the soil an amount of lime equal to about one ton of air-slaked lime, potassium equal to about 400 pounds of muriate of potash, and phosphorus equal to that contained in about 300 pounds of acid phosphate. One ton of unleached wood ashes per acre is a good application on marsh soils. Ashes are especially valuable for use on marsh soils on account of the potash they contain but also give good results on sandy soils since these usually need both lime and potash.

Leached wood ashes usually contain less than one per cent of potassium and rather more lime than unleached ashes. Frequently they may be obtained from dumps in a wet condition, which, of course, lowers the amount of actual lime contained in a ton. The usual application is from two to three tons per acre. They can best be used on marsh soils.

Coal ashes have no value as a fertilizer and no value as a source of lime.

NEW FACTS IN FARM SCIENCE

THE FORTIETH ANNUAL REPORT OF THE DIRECTOR
1922 - 1923
AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF WISCONSIN
MADISON

New Facts in Farm Science

IF I SHOULD attempt to speak of the progress of agricultural service during the last forty years I should emphasize the great change in its point of view—a change largely brought about by the agricultural experiment stations.

The work of the stations in earlier days was in large measure empirical—trying out and correcting traditional ideas and methods of agricultural practice. Its methods have now become those of applied science—applying and testing in agriculture the results of scientific investigation. Such new departments as genetics and plant pathology, with their new methods, are evidence of the altered situation. From these new methods have come results even more fundamental in the altered way of looking at the facts and processes of agriculture. The soil, for instance, is no longer thought of merely as a receptacle for the seed or even as a sort of chemical laboratory where sun and rain are constantly at work, for the benefit or injury of our crops. It is rather an aggregate of living organisms, many and diverse in kind and infinitely numerous, among which we plant the seed in the hope of introducing the cultivated plant as a sort of immigrant into a region already densely populated.

Such a change as this is not merely a "new fact;" it is a new outlook into nature—one of those views which disclose the possibilities of unlimited progress for agriculture. And the Wisconsin Experiment Station, which has served the state for forty years, will continue to be an indispensable and influential leader of that progress.

E. A. BIRGE, President.

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New Facts in Farm Science

Looking Backward

(Historical Summary 1903–1923)

by

H. L. Russell

AS ONE GROWS older, birthdays become gradually less important, but decades are not sufficiently numerous to be so easily ignored. This year marks the fortieth milestone in the history of the Wisconsin Agricultural Experiment Station, for this institution was founded in 1883, four years before the passage of the Hatch Act, under which Federal support was granted to the several states to permit of the establishment of the agricultural experiment stations. The tenth and twentieth annual reports of this Station have embraced a resume of the work of the preceding decades. In the early days of the station, all of the activities were incorporated in either the annual reports or the bulletins; but with the rapid expansion that occurred in staff personnel in the first decade of the present century, the policy of publishing much of the highly technical work in scientific journals was authorized, and the issuance of bound volumes of the annual reports as such was stopped. This resulted in a saving in printing of from $1,000 to $1,500 yearly, and made possible the wider use of these funds for the increased farmer mailing lists of later years.

The magnitude and scope of the work of the Experiment Station is now so great that a resume of the activities of an entire decade would be not only disproportionately large, but in these days of more rapid dissemination of results, perhaps too out-of-date to serve a worth-while purpose. We shall, therefore, limit our backward look to some of the general features of an historical importance that seem, perhaps, worthy of record in connection with the celebration of this, the fortieth anniversary.

Staff Continuity Essential to Permanent Station Policy

Increase in physical facilities is usually regarded as of most significance in comparing events of a chronological character, but of much greater value I feel is continuity in the time of service of the staff. For after all, research results of the highest value are very often dependent upon a continuance of definite lines of work that are carried through to completion, and this condition can in large measure be attributed to long periods of continuous service.

When this characteristic of the staff of the Wisconsin Experiment Station is considered, this very unusual condition is to be noted. Seven of the existing departments of the College still have the same

department head that was chosen at the time the department was organized. The shortest period of service is ten years. Two departments have each been under continuous control for twenty-nine and thirty years respectively, at which time they were started. The average for this group of seven departments is nearly eighteen and a half years. Six other departments have had only one change in the chairman of the department and are now officered with staff members who range from nine to twenty-five years of institutional service. Four departments have had three changes in administration, and only one department has had four different chairmen in the twenty years since its organization. This record is really unique and, it is believed, is not duplicated by another existing experiment station, although data have not been collected from other institutions to prove this point definitely.

Continuance in Projects for Investigation

Reference has already been made to the fact that long-continued projects are likely to be correlated with longevity in departmental administration. Many of the major lines of experimental effort have been under investigation for many years. Naturally these projects are matters of gradual growth, but it almost invariably follows that a major line of inquiry of any department will open up without fail subsidiary and cognate lines of research that make it highly desirable for further investigation to be made. One problem inevitably leads to another. Some of the most important work of the Experiment Station has been of this long-continued class.

The discovery of the vitamines and their relation to nutrition has opened up a veritable mine that has completely modified the science of both human and animal nutrition. In the eyes of the public the Babcock test is always referred to as one, if not the most outstanding contribution that has been made by the Station to dairy science. If significance is placed wholly on immediate application, undoubtedly this is true, for the foundation of dairy cattle improvement in large measure dates from the perfection of this instrument for measuring correctly and easily dairy cattle performance. The **why** of many a knotty problem is often of more importance than the **how**, especially from the fundamental standpoint of a more exact and correct understanding of the science of nutrition. The physiological researches of McCullom, Hart, Steenbock, and their several colleagues constitute one of the crowning pieces of scientific investigation in the current century and they will long stand among the great achievements of the Wisconsin Experiment Station.

The influence of environmental factors such as temperature, humidity, soil moisture, and the like have developed a new point of attack in plant disease research that was started in the realm of abnormal physiology, i. e., the pathology of plant diseases by L. R. Jones and his staff. So important has this field of investigation become that special equipment under accurately controlled greenhouse

conditions has now been provided which is of the highest importance, not only to the Plant Pathology staff, but to the workers in normal plant physiology, botany and plant nutrition, and agricultural chemistry as well. Weather is now produced at order, and its effects on the incidence of disease as well as on the well-being of the host plant are readily tested. By this accurate experimental control, positive results can be definitely secured in a comparatively short time when compared with the tedious observational method that required the piling up of a large amount of data over a period of years before the underlying law could be detected, if it could be determined at all.

Cases could be multiplied in large number which would illustrate the importance and value of long-continued projects. Years of effort have been put on the study of the alfalfa problem to adapt this important forage plant to our system of production. The correlation of this investigation to the physiology of the plant, the supplying of suitable soil conditions by amending the soil through the application of available lime, the inoculation of the seed to fix the nitrogen of the air, the selection of proper varieties and nurse crops, and the proper times for cutting and harvesting the crop as well as methods of curing have been worked out.

The work of R. A. Moore in producing the well-known Wisconsin strains of corn, barley, and oats has caused a world-wide dissemination of these Wisconsin seeds and at the same time lengthened the crop list of the state as well as greatly increased the per acre production of these important grains.

The work of King, Whitson, Truog, and others has shown how better to utilize the fertility in our soils by proper cultural practices, and the balancing of the ingredients through the addition of the various forms of lime locally available and the use of specific fertilizers that fit in with the Wisconsin farming systems.

Tuberculosis eradication of cattle was advocated in Wisconsin in advance of any state west of the Appalachian Mountains and to it in considerable measure can be attributed the splendid reputation now enjoyed by dairy cattle from our state. Further cases might be cited in large numbers if space permitted.

Continuity in Administration

The history of the Wisconsin Station has also been very unusual in that there has been only one change in administration in the forty years of service. Prof. W. A. Henry, when first appointed in the University of Wisconsin, was made Professor of Botany and Agriculture in June, 1880. The first appropriation by the State for experimental work was in 1881 when $4,000 was given Professor Henry for experiments in making sugar from amber cane. It was in 1883 that the State organized a State Experiment Station. Already the experimental station idea had begun to take root in other states as well, Connecticut having organized the first in 1875, and four or five others had been established in the East.

While the Station was started in 1883 with three professors making up the staff, it was not until 1886 that Professor Henry was actually made Director of the Station, which position be continued to fill as well as that of Dean of the College from 1889 until he laid down his duties as an administrator in 1907 after a period of service to the University and the State of twenty-seven years. It was during this long, uninterrupted service that the foundations of the experimental work in most of the basic departments were organized.

Up to 1907, the year that Professor Henry resigned as Director, nine departments had been established in the Agricultural College.

In that year H. L. Russell was made Dean and Director and he has been continued in that position from that time to the present. These two successive administrators of twenty-four and sixteen years successively are exceedingly unusual in the history of any single experiment station.

Departmental Development in Last Two Decades

Since the beginning of the present administration seven new departments have been organized and two reorganized. Most of this expansion took place between the years 1908 and 1913 when there was a very rapid growth in the number of students in the Agricultural College as well as a marked expansion in the scope of the work for the State at large. The very close connection between the work for the students and that associated with the experimental work makes it impossible to separate the departmental organizations. The informational service of the College was first put on a definite departmental basis in 1908 by the establishment of an agricultural editor and the organization of agricultural journalism courses for students. In the same year a department of education was founded to supervise the training of teachers who were then entering the high school system in large numbers as teachers of agriculture. It was also in 1908 that the foundation was laid for the development of the extension service which has coordinated the efforts of the College to carry the results of research work of all types to the entire State. Prof. K. L. Hatch was made Assistant Director of this service in 1909. Wisconsin was in the lead in the development of this statewide service on a definite foundation several years before the problem was taken up nationally under the Smith-Lever law, just as she had organized her agricultural experiment station before the nationwide movement took effect.

In 1909 the department of Home Economics was transferred by the Board of Regents from the College of Letters and Science to the College of Agriculture and the department completely reorganized. Of late years this department has been assigned research funds to enable definite experimental work to be undertaken in this important field of human service.

In 1909 the departments of Plant Pathology, Poultry, and Agricultural Economics were established. Wisconsin was one of the first

institutions in the country to recognize the necessity of definite economic research, long before this movement assumed the proportions which it has more recently acquired in the public mind. In 1910 the department of Veterinary Science was reorganized and its work put on a laboratory basis the same as Bacteriological and Pathological work. Economic Entomology was started in 1911 and the field of Genetics (first called Experimental Breeding) in 1913.

For the past ten years no further departmental additions have been made. In 1915 work in Land Clearing was organized but was assigned to the department of Agricultural Engineering which at this time also included the subject of drainage. There is but little probability that any further differentiation in agricultural activities will need to be made, as the obvious field of inquiry has now been well developed.

Coordination of Research and Extension Activities

The Wisconsin College of Agriculture early developed a differentiation between research work at the Station and that of the Extension service which was carried on throughout the State. In many colleges the extension work was developed as a separate organization or department, independent, more or less, of other existing departments so far as the field control of staff personnel was concerned.

The Wisconsin policy was from the outset developed on a different principle. The departmental unit constituted an organization in a particular field of endeavor, and as a department of thought should, it was felt, concern itself with all three aspects of work—teaching of resident students at the College, experimental research, and the extension of such research to the residents of the state.

At the outset, however, it must be realized that the work of some departments would concern itself in particular with one or at least two of these lines. Thus, the Home Economics Department for many years was engaged primarily with teaching; then it undertook extension and now research activities. Agricultural Chemistry and Genetics, however, have little opportunity to engage in extension work. But even some of the laboratory types of sciences that normally would not have found a wide-spread contact in the field of extension have been remarkably successful in cultivating these external relations as Bacteriology has through its distribution of legume cultures which is now expanding so rapidly.

Branch Experiment Station Policy

Research work is often broken up and carried on at several places in the State. Manifestly, there are many problems that are peculiar to certain regions and can not therefore be conducted at any one point, and in disposing of them regional work is required. Sometimes, however, political influence, especially local politics, divides the work over as many regions as possible.

To render the necessary regional service, five branch stations have been established in areas of the State differing widely in soil or climatic conditions. These are located at Ashland (heavy red clay), Spooner (light sandy loam or jack pine soil), Marshfield (fine-grained silt loam), Hancock-Coddington (very light sand and also peat), and Sturgeon Bay, where the fruit problems as well as the peculiar farm needs of the Door Peninsula are considered. Naturally it costs more to split up the work in this manner and workers usually cannot accomplish as much when divided as when working as a unit on the home station at Madison. But the results which have been obtained on these stations have amply justified their establishment and could not have been carried out at the Central Station at Madison.

While these branch stations are representative of the main types of farming found in the State, and while they are necessarily far apart, they are, nevertheless, regarded as subsidiary parts of the home organization at Madison and are so administered. Different College departments may carry on work on any of these locations, though soils, field crops and live stock have been the mainstay of these operations. The department specialist in charge of the predominating type of work commonly acts as executive representing directly the Director of the Home Station. This plan has been one of economy and by it excellent results have been attained at a minimum cost.

Development of the Agricultural Library

Recognizing the importance of an agricultural library, Dean Henry began early to lay the foundations for one at this College. He was an enthusiastic collector of books who searched diligently in the shops of both America and Europe. Even today he brings to our attention lists of rare books which he finds in book shops as he travels. From the modest beginning in South Hall, the Wisconsin agricultural collection gradually grew until it became one of the very best in the country. The Library is particularly strong in nutritional and biochemical material. Excellent collections have also been made in the newer fields of plant pathology, agricultural economics, and also in entomology, by virtue of the Miller Memorial Library, greatly increasing thereby the size of the Agricultural Library. Nearly a mile of shelving is required for the 23,000 bound volumes and 18,000 pamphlets in the collection now housed in the agricultural archives.

Development of County Agent System

The results of experimental research, unless actually carried into the field and put into practical use by the farmers of the State, are without avail. It is, therefore, important to recognize the close relationship which exists between the work of the Experiment Station and that of the Extension Service, more particularly that phase which is concerned with the development of the County Agent system. The idea of establishing a resident representative of the University in

the several counties of the state, in which the teachings of the Agricultural College could be put into more direct use, was drawn from the experience of Canada, where this system was in operation for several years prior to its installation in Wisconsin in 1912. From the very beginning it was felt that the development of this work should rest upon legislation in which the support of the system was from general taxation. At that time there were numerous propositions to support similar agencies by special organizations of farmers, such as railroads, chambers of commerce, bankers and other financial groups. If the system was worth while to develop in a permanent way, it was felt that the support should be by public taxation. The establishment of the first county agent (first known as county agricultural representative) was made in Oneida County in the fall of 1912. The growth of this work was slow but steady, first expanding in the new North where new ideas of this sort seem to lodge more readily.

A marked impetus in the development of the work occurred when the Federal law known as the Smith-Lever Act was passed which appropriated funds from the Federal Treasury to supplement those of the state in a wider introduction of this system. During the war the work was still farther expanded owing to the necessity of every possible effort being directed in the matter of food production. In this expansion of the work caused by the war it was the purpose of the College to keep the emergency work on such a basis that the counties would have full option to act for themselves and not to be forced to continue the county agents unless they found it was worth while. As the law establishing this work made the development of these agencies simply permissive rather than mandatory upon the county, the work has grown in extent and importance only so fast as the counties themselves realized that it was an economic advantage for them to install such representatives.

The Smith-Lever Act also permits the establishment of home demonstration agents that do for the rural home a work somewhat comparable to that which the county agent accomplished for the farm. In Wisconsin this work has never made the headway that it has in other states, owing to the fact that the development of the system of county nurses, which was made mandatory in the original act, practically precluded the development of the home demonstration agent idea.

New Facts in Farm Science

H. L. RUSSELL AND F. B. MORRISON

IN THE READJUSTMENT that Wisconsin agriculture must make in adapting itself to changing economic conditions, there stands out with startling clearness the one fundamental fact that the most feasible way for us to lower our production costs—say, in producing milk (live stock and live stock products now make up over 80 per cent of our farm income)—is to grow as much as possible of the necessary feed that should be used with our stock to secure most profitable returns. Certain concentrates we must purchase from outside, but it is impossible for us to continue purchasing large quantities of coarse forage, such as hay, and bring it into the state over a long rail haul, and expect that profits can be maintained. Wisconsin has now 2,800,000 dairy animals and we could use to good advantage two million acres or more of leguminous hay crops.

Many hundreds of thousands—and in all probability millions of dollars—go out of the state annually for such feed expenditures. Cheap

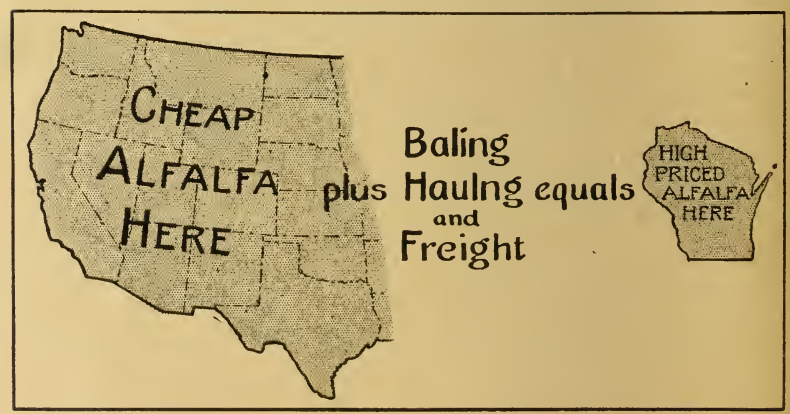


FIG. 1.—WISCONSIN FARMERS CAN GROW ALFALFA CHEAPER THAN THEY CAN BUY IT

We annually spend vast sums for alfalfa hay from the West. Much of this cost is due to the long freight haul.

alfalfa from the West, plus heavy freight rates (often more than the alfalfa originally costs) means high-priced forage when delivered here.

Energetic efforts must be made to increase our legume production. For alfalfa the soil must be in a proper condition. Alfalfa is a lime-loving legume and only grows luxuriantly when there is an abundance of available lime. Thousands of square miles of even our most excel-

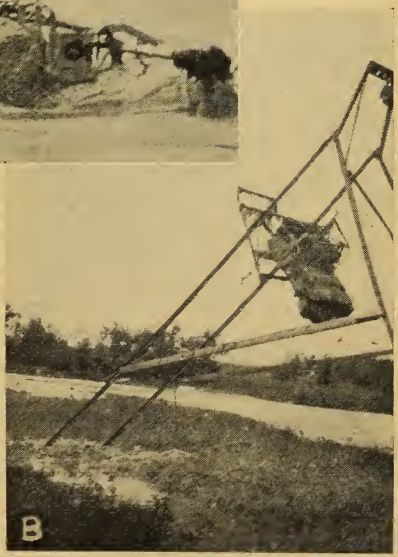
lent soils are often too deficient in this material to meet the needs of this particular crop, although they may be successfully used for less sensitive legumes. A thorough and complete understanding on the part of our farmers with reference to their soil needs is basic to the most successful type of agriculture.

Limestone and Marl Lower Feed Bills

THAT VARIOUS forms of lime are helpful to many soils has been known in the past, but it was often difficult to get suitable material. The cost of shipping lime, or frequently the team haul from the point of shipment to the farm, made it difficult for farmers to use sufficient lime in sections where it was needed most.

Recent developments in using Wisconsin's numerous marl fields, however, have greatly altered the situation. Nature has endowed Wisconsin with lime deposits in the form of marl that are often easily available and located where they are most needed to remedy soil acidity.

(A) Marl dredge emerging from the lake with its load of "white gold."



(B) The marl dump which makes it possible to elevate the material to a place where it can be loaded onto the farmers' wagons.

FIG. 2.—DREDGING MARL FROM THE BOTTOM OF A WISCONSIN LAKE

Already many thousand tons of this material have been excavated by the eight machines now operating in the state, according to the Soils Department. In some sections the marl is in sloughs and valleys so well drained that it can be loaded directly upon wagons. Excavating machinery is, however, required when the marl is taken from lakes or rivers. Homemade dredges are operated successfully by groups of farmers, but large excavators are used where a great deal of excavating is done in one place.

These marl deposits often exist in enormous amounts in many of the old lake beds and can usually be made available more easily than other forms of lime. Hundreds of these marl deposits have been definitely located by prospectors from the Department of Soils and others who have been working on them during the past year, and it is probable that many new deposits will be found in the numerous old lake beds existing in Wisconsin.

The theory is that the lime in these marl deposits was originally washed out of the soil by surface waters and carried down the valleys into the lakes where it was precipitated possibly because of the presence of certain plants, particularly a species of algae known as "Chara." Frequently veins of iron ore are found deposited with the marl, and it is possible that the presence of iron in the water may have had something to do with the lime precipitation.

Local Grinding Supplied 70,000 Tons. The lime rock outcrops found in many sections of southeastern Wisconsin, as well as in some parts of the driftless region to the southwest, are another source of agricultural lime that has been but little used. Since 1918, however, the many limestone grinding machines in Wisconsin farm communities have ground over 70,000 tons of limestone.

In growing a high-class dairy ration and in cancelling the large feed bills to which many of our dairymen have been subjected in the past, lime will play a leading part. The material can be applied by lime-spreading machines, ordinary manure spreaders, or the end-gate seeder type of spreader. Distribution by hand from the wagon is also common.

The excellent results from liming in recent years are generally known. On the several fields where the results of marl have been observed, similarly good results were obtained. John Rogers, of Oxford, tried to grow alfalfa for ten years, and although he spent considerable time and money, he was not successful until he used marl. He now has splendid fields of alfalfa and was able to grow good hay this past year while most of his neighbors had none. Emil Johnson, Grantsburg, tried alfalfa twice and it failed to grow. Then he put marl on the soil and he now raises four tons of hay per acre. He raised about 120 tons of alfalfa hay this past year and is well supplied, while others are looking elsewhere for hay. Last year Mr. Johnson also raised three bushels of Grimm alfalfa seed per acre, which netted a return of about $70 per acre.

Soils Laboratory Serves Farmers

LABORATORY TESTS which substitute definite knowledge for guesswork in the matter of soil conditions have a distinct community value and the reports thereof have also been frequently found useful to farm owners in determining land values. The records of the State Soils Laboratory show that in the past year, during which a total of 313 farms were examined, a more extensive service was rendered to the farmers of the state than in any previous year. Detailed surveys and chemical analyses were made, as well as complete reports to each individual farm owner.

Analyses of over 1,800 soil samples were made by C. J. Chapman, R. P. Bartholomew and E. J. Graul (Soils) incident to the examination of farms for the determinations of total nitrogen, total phosphorus, lime requirement, and total potash. The department was also called upon to render over 750 limestone analyses and between 500 and 600 acidity tests, all on miscellaneous samples.

Since it is necessary that a small fee be charged to cover a part of the expense involved in this work, it has been found desirable to tie up the work of the State Soils Laboratory and the Soils Survey so that the service can be rendered more cheaply to a number of farmers in the same county or community who may request the soil analysis at the same time. Such an arrangement was made in Pierce county with very gratifying results.

New Tests for Soils

OWING TO THE growing demand by county agents and extension workers for a simpler test for soil acidity than the Truog test, which is now commonly used, a study has been made on the subject during the past year by E. Truog (Soils). As a result, a new test has been devised which gives promise of filling the needs.

Soil Acidity Test. In this new test a measured amount of soil is treated with a little water and calcium carbonate. If the soil is acid, carbon dioxide is evolved in proportion to the degree of acidity. A small pocket apparatus has been devised for conducting the process and measuring the carbon dioxide evolved. The test makes possible the differentiation of soils into fifteen degrees of acidity and the results thus far correlate very well with greenhouse and field results on the use of lime. If this device continues to prove successful, it will probably find wide use as a simple field test and also as a laboratory test.

Analyzing Soil for Potassium. During the past year, considerable attention has also been given to the development and perfection of a rapid method of potassium determination by Mr. Truog. The methods ordinarily used at present are long and time consuming, for which reason the extent of their use becomes limited; there seems to be a considerable demand for a short practical method for determining the potassium content of soils.

The method under investigation makes use of the well-known color reaction for potassium. This element, when heated in a flame, gives a very distinct and characteristic violet color. The amount of color is dependent upon the amount of potassium present. In the new method the soil solution of unknown potassium content is compared with standard solutions as regards the amount of color produced. A special apparatus has been devised for making this determination, and the results thus far indicate that it is going to be workable.

The method is very short: the soil is simply extracted with water, filtered, and then a drop of the extract is evaporated on a platinum loop along with a drop of standard solution on another loop, and the two are then simultaneously placed in the flame and the comparison made. Work done on this method so far indicates that its practical application is highly probable.

Determining Nitrates and Ammonia in Soils. In order to provide an improved method for the determination of nitrates and ammonia in soils, H. J. Harper, working under Mr. Truog, has been working on the problem. A new method which gives promise of much practical value has been worked out.

In the method for determining nitrates, the soil solution is clarified by treatment with a combination of copper sulphate, calcium hydroxide, and magnesium carbonate. It is essential that all the suspended coloring matter be removed from the soil solution without loss of nitrates and this treatment accomplishes this more perfectly than any other known procedure.

The determination of ammonia in soil has never been very satisfactory. In former methods, the soil suspension was distilled with a weak alkaline material and the ammonia driven out. This usually resulted in the formation of ammonia from organic matter of the soil and hence gives high results. In another method, the ammonia was liberated by aeration with sodium carbonate, but this method has been found too long and tedious. In the newer methods recently devised in the Soils Laboratory of this station, the ammonia is first extracted from the soil with a strong solution of potassium chloride. This displaces the ammonia from the various compounds of the soil. Magnesium oxide is then added to the soil extract and the ammonia expelled by distillation and then measured by titration. The method has been tried on soils of known ammonia content and has given satisfactory results. It is, therefore, probable that the improved method of determining both nitrates and ammonia in soils will become valuable in the making of practical determinations.

Activated Sludge Conserves City Waste for Fertilizer

THE AMOUNT of fertilizing material which has in the past been wasted in the disposal of city sewerage is enormous. People interested in agriculture and in conservation measures have long been concerned with the problem of conserving the wastes which, if they could be measured in money, would doubtless run into many

FIG. 3.—COMPARISON OF SLUDGE MIXTURES AND MIXTURES CONTAINING DRY BLOOD

This fertilizer was applied in the hill. Sludge applications were at the rate of 200 pounds per acre and dry blood mixture at 120 pounds per acre. Note the excellent showing made by the sludge.

millions of dollars annually. Moreover, the dumping of these materials into our rivers and lakes by our cities has so contaminated these places as to make them dangerous sources of water supply and even rendered them undesirable for use by bathers in the summer.

In 1913 the Wisconsin legislature passed an act authorizing the city of Milwaukee to create a sewerage commission to study this problem, and out of this action has grown a far-reaching work which has resulted in the making of preliminary studies on the newly discovered activated sludge process beginning in 1915.

After several years of trials, the Milwaukee Sewerage Commission recommended the adoption of the activated sludge process to solve the sewage problem of Milwaukee and its suburbs covering an area of 96,800 acres and containing a population of about 575,000 people. This area has a dry weather sewerage flow of about 75,000,000 gallons per day, which has up to now been very largely dumped into the Menominee, Kinnickinnic and Milwaukee rivers, and Lake Michigan, the source of Milwaukee's water supply.

The Activated Sludge Process. Briefly, the activated sludge process provides for the removal of coarse material from the raw sewage by means of bar screens, after which the liquid flows through sedimentation chambers where the mineral matter settles out. From the sedimentation chambers the sewage passes through a process of aeration, in which it is mixed with a little of the already activated sludge which

acts as a starter and then a large amount of air is forced through it from below, to aid in the oxidation process and in the development of bacterial action. After six hours of this aeration and contact with activated sludge, about 95 per cent of the organic matter in the raw sewage is precipitated to the bottom, leaving nearly clear water on top. After a little more settling, the liquid on the surface is discharged into the lake practically clear and colorless and showing an average reduction of 98 per cent in bacteria and 97 per cent of suspended matter. The remaining precipitated material or sludge then

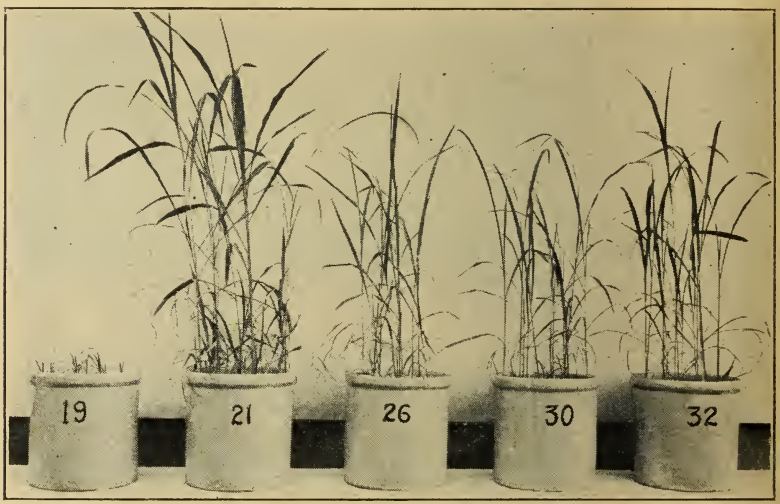


FIG. 4.—SLUDGE IS A CONVENIENT SOURCE OF ORGANIC NITROGEN

Sludge was applied at the rate of 1,000 pounds per acre. All cultures were supplied with soluble phosphorus and potassium.
19—No nitrogen
21—Sodium nitrate
26—Regular sludge
30—Spent acid sludge
32—Regular Sludge with lime

enters the plant for further reduction. At this point it has already been reduced to 15,000 gallons per 1,000,000 gallons of original sewage, but further dewatering is necessary. This is accomplished by continuous vacuum filters and treatment with sulphuric acid or alum. The result of the process is a dry fertilizer material, dark in color, containing 6 or 7 per cent of organic nitrogen and 2½ per cent of phosphoric acid.

In order to study the practical value of the sludge material as a fertilizer, the Milwaukee Sewerage Commission established a fellowship at the College of Agriculture, and O. J. Noer, under E. Truog (Soils), has been working on the problem. Since about $25,000,000 are to be expended by the city of Milwaukee and surrounding centers of population in the building of a plant and the necessary sewers which will produce in the aggregate about 100 tons of activated sludge each

day, the problem of using this material available for fertilizer to best advantage is one of considerable economic interest in agriculture as well as to the city of Milwaukee and all other cities facing a similar problem in the disposal of their sewerage.

Research on the subject has shown that this fertilizer compares very favorably with other forms of fertilizer that have been in common use and, since there is very little odor connected with it, the material in itself is not nearly so offensive in handling as other fertilizers of organic origin. Excellent results have been obtained by using this material in connection with such fertilizing constituents as rock phosphate and acid phosphate, and it is probable that it will find a very considerable market for use with mixed fertilizers by virtue of its large percentage of organic nitrogen and good handling qualities. It seems also to be particularly adapted for use on lawns and golf courses, for which purpose there is a considerable fertilizer demand at the present time. Sheep manure which has been used extensively

FIG. 5.—SUDAN GRASS GROWING IN QUARTZ CULTURES WITH DIFFERENT FORMS OF NITROGEN

Sludge 1,000 pounds per acre and others giving equivalent amounts of nitrogen. Soluble phosphorus and potassium were supplied in all cases. The sludge was superior to sheep manure.

87—No nitrogen
89—Ammonium sulphate
91—Sludge (H_2SO_4)
93—Sludge (Alum)
95—Sheep manure
97—Tankage
99—Blood meal
101—Cottonseed meal
103—Fish scrap

in this work is not so satisfactory as activated sludge, according to the experimental workers. Trials on golf courses at Madison and Milwaukee indicate that this material can be applied in large quantities without injury to the grass and with excellent response in plant growth.

Results with other crops indicate that sludge has a very definite fertilizing value and is well adapted to the use of crops having a long growing season, as corn and potatoes, especially on light-textured soils such as the sandy loams. An activated sludge with an estimated value of perhaps $20 per ton should prove an efficient and economical fertilizer with a wide range of application in Wisconsin's farming system and at the same time prove an efficient way of conserving the wastes hitherto dumped into lakes and rivers by cities.

Fertilizers Bring Good Results on Peat

TRIALS AT Coddington Station during the past year were considerably affected by drouth, and in addition frosts did damage as late as June 29 and as early as August 22. The freeze on September 13, killed practically all of the summer crops, the temperature going as low as 21° F. for two consecutive nights.

One of the problems in the development of these peat areas is the selection of crops adaptable to the soil and climatic conditions. With this purpose in mind a number of trials were undertaken with forage crops, potatoes, and parsnips to determine their response to fertilizer treatment. See Table I.

TABLE I—RESULTS FOLLOWING UNIFORM TREATMENTS OF 400 POUNDS OF 0-8-24

Crop	Yield per acre	
	Fertilized	Unfertilized
Oat and pea hay (average of 4 plots)	4,600 lbs.	1,650. 0lbs.
Soybean hay (21-inch rows Av. of Manchu) (Black Eyebrow and Ito San).	3,286 lbs.	1,182.0 lbs.
Soybean hay (Solid drills)	4,233 lbs.	1,422.0 lbs.
Millet hay	4,760 lbs.	2,647.0 lbs.
Sunflower silage	27,400 lbs.	3,960.0 lbs.
Potatoes (Early Ohio Av. of 2)	136 bu.	32.3 bu.
Potatoes (Rurals, 1 plot)	151.4 bu.	31.6 bu.
Potatoes (Triumphs, Av. of 2)	79.9 bu.	28.0 bu.
Parsnips	16,870.0 lbs.	Not harvested

FIG. 6.—PROPER FERTILIZERS BRING RESULTS WITH POTATOES ON PEAT

Peat is recognized as splendid potato soil, and high yields are obtained when soil deficiencies are supplied. Results are from Price County.

On the fertility plots, potash continues to give the most pronounced results whether supplied in manure or in the commercial form. In trials with clover it was found that, where $4.50 worth of potash alone was expended per acre in 1920, the return from the fertilizer in this past year was 677 pounds or $6.77 worth of hay per acre, or $2.27 more than the cost of the fertilizer applied over three years ago. In other words the fourth crop grown after the application of the potash still more than pays for the fertilizer in one year. However, the difficulty will generally obtain that farmers on this hazardous soil type will not generally be in a financial condition which will enable them to buy fertilizers for which a direct cash outlay has to be made.

Tillage Trials at Marshfield

TILLAGE trials have been among the first experiments undertaken at this branch station; and while the work over a series of years indicates quite clearly that deep tillage and subsoiling do not pay on the staple crops the following conclusions may be drawn from the work to date:

1. Deep plowing and subsoiling have not been found profitable.
2. Corn on a five-year average has given the best yields on spring plowed land followed by ordinary fall plowing to a depth of 6 to 7 inches.
3. Deep tilling has given the lowest yields.
4. With oats, nine-year tests have shown a trifle higher yield on spring plowed than on ordinary fall plowed land; likewise deep tilling gave the lowest yield. In clover and timothy the results are variable.

Tillage Trials at Ashland

WORK ON the plots devoted to tillage has been continued on the Superior red clay soil at Ashland in the past year. The results generally agree with those of recent trials. These points summarize the results and conclusions:

1. The use of the deep tilling machine is unprofitable; in fact, the yields are on the whole practically the same as those from ordinary plowing. In some cases they are even less.
2. The use of the subsoil plow shows some improvement over 6-inch fall plowing. This is especially noticeable on the rutabagas. For root crops, therefore, deep stirring of the soil seems to be beneficial but since this crop occupies such a relatively small proportion of the plowed land it hardly seems advisable to urge subsoiling.
3. Shallow plowing is poor practice.
4. In general, plowing to a depth of about 7 to 7½ inches in the fall is recommended to red clay farmers.

Fertilizer Trials on Light Sandy Loams (Spooner)

CHANGES have been made in the fertilizer treatment of potatoes at the Spooner Branch Station the past year. Various fertilizer treatments distributed over 23 plots have been applied to potatoes in a rotation of potatoes, oats and clover.

Since the work has been started only in the past year, no detailed results are available. During the first year, however, the best results were obtained when two-thirds of the fertilizer was applied in the hill and one-third broadcasted. By this method the fertilization of succeeding crops, such as grain and clover, is considerably benefited.

Green Manuring Experiment. For a number of years green manuring trials have been conducted at Spooner to determine the effect of the incorporation of organic matter upon the growth of oats, corn, potatoes, and clover. No stable manure or commercial fertilizers are used and green manure crops are plowed under at two different times in the rotation. They are utilized by alternating soybeans and lupines with the corn and seeding clover and rye on the potato plots after the crop is harvested.

The results so far indicate that the oat crop shows about a 50 per cent increase where green manuring crops of various kinds are plowed under. Corn silage yields have been highest on unmanured lands for the reason that the green manuring crops have been grown in alternate rows at the same time as the corn.

On a four-year average the potato yields run from 12 to 14 bushels per acre higher on plots where green manuring was done than on the check plots, but very little variation was shown during the past year. There was considerable increase, however, in the clover crops grown on the green manure areas, the difference obtained in favor of manured plots was from 25 to 30 per cent.

Top Dressing Better than Plowing Under of Manure at Spooner. Trials conducted for several years on the rate and the method of application of manure show in general that the top dressing method is more satisfactory than plowing under though the difference is not very large.

On the sandy soils of this region the use of 400 pounds of gypsum per acre in addition to 4½ tons of top dressed manure was also tried, but the results indicate that it is not justified upon this type of soil.

The trials just completed also indicate that small applications of manure and the covering of more land is a desirable practice. The results, when distributed over a three-year period, are distinctly in favor of smaller applications when applications of 4½ and 9 tons per acre are compared.

Crops Respond to Lime at Spooner. While the past year was exceedingly dry and the hay crop in general was short in the region of the Spooner branch station, the first crop showed an increase of 7 per cent on fields that had had a two-ton application of lime per acre. On the second crop these same fields indicated an increase of 17 per cent in favor of the lime application.

Fertilizer Experiments at the Marshfield Station

COMPARISONS of fertilizers such as rock phosphate and acid phosphate supplementing stable manure, the use of ground lime stone, the use of gypsum and potash, and others, have been continued at Marshfield by F. L. Musbach. The following table summarizes the results of the more important work.

Table II—Results of Fertilizer Experimental Work at Marshfield

Plots	Treatment	Clover	Oats	Barley
		Lbs.	Bu.	Bu.
1	Crop residues, 800 lbs. rock phosphate, lime	2,310.3	57.92	25.55
2	Untreated	1,196.2	47.46	17.04
3	12½ tons manure, lime	2,055.9	56.71	31.19
4	10 tons manure, lime, 800 lbs. rock phosphate	2,123.5	62.75	29.69
5	10 tons manure, lime, 400 lbs. acid phosphate	1,930.5	56.61	33.03
6	10 tons manure, lime, 800 lbs. rock phosphate, gypsum 450 lbs.	2,080.6	62.23	22.79
7	10 tons manure, lime	2,232.4	54.37	19.57
8	10 tons manure, 800 lbs. rock phosphate, lime	2,135.1	54.71	25.44
9	10 tons manure, 400 lbs. acid phosphate, 200 lbs. KCL, lime	1,849.6	59.13	30.96

Rock phosphate is making a better showing in trials on the Colby silt loam than formerly owing to the growing amount of organic matter in the soil. Apparently the larger amounts of organic matter are helpful in making the rock phosphate more available as a plant food. With oats, rock phosphate gives better results than acid phosphate; but with barley the acid phosphate seems to be the better.

Because of the constant propaganda favoring the use of gypsum on dairy farms, considerable interest is attached to the results obtained from a use of this material. Gypsum has been applied to the top dressing on the new seeding and so far has shown no beneficial effects on clover and no notable differences on other crops in the rotation. The conclusion is warranted that the use of gypsum in the growing of clover or other crops does not pay.

Potash fertilizer applied with stable manure has not given any satisfactory results during the past two years. While slight increases were obtained in oats, potash has on the whole not given any profitable yield increases.

Fertilizer Trials on Red Clays (Ashland)

EXPERIMENTAL work with fertilizers has been continued on the clay soils of Ashland on a number of plots during the past year with a rotation consisting of corn, barley, oats, and clover.

TABLE III—RESULTS OF VARIOUS FERTILIZER TREATMENT ON BARLEY FOR 1923 AND ON CORN FOR 1922

Plot	Treatment	Barley	Corn-1922
		Bu	Bu.
1	Manure and rock phosphate	21.42	19.10
2	Manure and acid phosphate	24.76	21.82
3	Manure only	17.18	19.19
4	Residues and rock phosphate	16.56	20.19
5	Untreated	9.53	11.65
6	160 lbs. acid phosphate, 50 lbs. potash, and 75 lbs. nitrate of soda, for corn, oats, and barley	24.58	15.79
7	10 tons manure, 125 lbs. acid phosphate and 50 lbs. nitrate of soda for corn and 125 lbs. acid phosphate and 50 lbs. nitrate of soda on barley	25.39	18.86

The field on which this fertilizer work was done has been cropped for twleve years, at which time it was first broken up. The table indicates that even in so short a cropping period the yield of farm products becomes unprofitably low unless fertility is maintained by a well-planned fertilizer treatment. Applying manure at the rate of ten tons once in four years has practically doubled the yield of barley and increased the yield of corn nearly 75 per cent. Supplementing stable manure with acid phosphate increased the yield over manure only by 44 per cent in the case of barley and 15 per cent in the case of corn. Results with phosphates supplementing manure have given consistently good returns and this practice can be recommended upon the red clay soil of the Superior region.

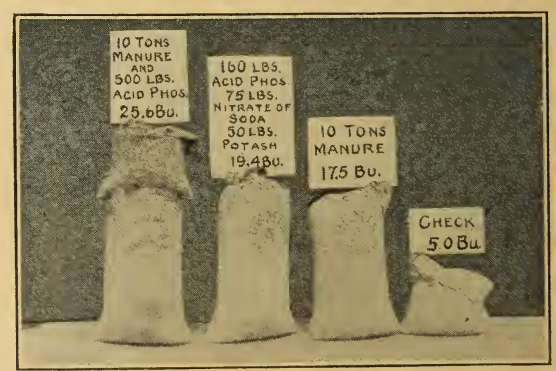


FIG. 7.—FERTILIZATION INCREASES BARLEY YIELDS ON SUPERIOR RED CLAY

The heavy clay bordering Lake Superior shows response to proper fertilization. Barley yields of 1923 at the Ashland Station: Check—3 bu. per acre; 10 T. manure—17.5 bu. per acre; 160 lbs. acid phosphate and 75 lbs. sodium nitrate—19.4 bu. per acre; and 10 T. manure and 500 lbs. acid phosphate—25.6 bu. per acre.

While under our system of farming, the use of commercial fertilizer in supplanting stable manure is not recommended, the results at Ashland indicate that satisfactory yields may be derived by following good rotations and depending only upon commercial fertilizers. The following general fertilizer program for the red clay soils seems to be a practical one in the light of experimental work:

1. Careful conservation of stable manure produced on the farm.
2. Supplementing manure with soluble phosphates to the extent of 300 to 350 pounds per acre.
3. Distributing the phosphates over two crops if possible; i. e., half to be mixed with the manure at the time of spreading; the other half broadcasted with the small grain with which clover or other legume seed is sown.

Drainage Results on Colby Silt Loam (Marshfield)

THE RESULTS of drainage work at Marshfield have been observed by Mr. Musbach for a period of years.

Table IV—Data on Alfalfa Over a Period of Three Years

	Potatoes	Alfalfa				
		Third year		Second year		First year
		1st Crop	2d Crop	1st Crop	2d Crop	1st Crop
	Bu.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
4 rods from tile	154.15	2,710.9	853.1	2,271.8	495.3	2,349.9
3 rods from tile	152.73	3,012.5	1,034.3	2,160.9	476.5	2,270.2
2 rods from tile	143.73	3,265.6	1,109.3	2,145.3	454.6	2,290.6
1 rod from tile	142.82	3,537.5	1,226.56	2,220.2	485.9	2,287.4

During the first years after seeding of the alfalfa the crop was heaviest farthest away from the tile. The same was true during the second year, but in the third year a reversal took place and the crop was notably heavier where close to the tile. Observations with potatoes also show that during the last years this crop is appreciably better at a greater distance from the tile than close to the drainage lines.

The alfalfa yield of the third years was appreciably higher than those of the previous two years. This applies especially to the second cutting of the season. A study of the root system of the alfalfa indicates that during the third year this crop had rooted to a depth of seven feet through the "hard pan" subsoil which is quite generally found in the Colby silt loam region. The second year alfalfa had penetrated only to one-half that depth, and the first year it extended down to a depth of only about two feet. The increase in yield of this crop as well as its reversal in reaction to the tile drainage may be the result of this difference in depth of root development, though the exceedingly dry season of the past year may have had something to do with it.

Alfalfa Resists Drouth on "Blow" Sands at Hancock

IN SPITE of extremely dry weather alfalfa made an excellent showing on the light sand at the Hancock Station during 1923. From April 1 to September 1 only 11.97 inches of rain fell and of this only 7.68 inches came in showers exceeding ½ inch at a time. Clover, which had been a good stand in 1922, suffered so severely from the drouth that only about a quarter of a crop was harvested. The alfalfa averaged 1.3 tons of hay per acre for the season.

Alfalfa has been tried previously over a wide range of sandy loams and the dark colored sands, but this is probably the first demonstration which shows that this crop can be grown successfully on Plainfield sand, which is practically a blow sand and common in sections of central Wisconsin. The four-year average of alfalfa at Hancock is now 1.5 tons per acre of hay per year, which in many cases is equivalent to the value of the land itself.

In order to grow alfalfa on these worn out sandy soils, liming and inoculation are always essential. Top dressing with manure and seeding without a nurse crop seems to be preferable as a cultural practice. The best time for seeding the crop is dependent upon the rainfall, though early seedings as a rule have the best chance of success and permit of a reseeding of the crop in June, or later, in case the earlier seeding dries out.

Examination has shown that in these sandy fields certain individual plants of alfalfa were less affected by drouth than others, and a careful study of these proved the reason to be the deeper rooting of these particular plants. Seed was gathered from these more hardy plants with the intention of reproducing them in larger numbers.

Soybeans and Corn on Hancock Sand. The yield of corn at Hancock for the past year was 3.5 tons of silage per acre, and soybeans on unfertilized land produced from 1,000 to 1,500 pounds of hay per acre when the earlier varieties were used.

While liming and inoculation are very important in the culture of leguminous crops on this sand, the results show that success with clover cannot always be obtained without fertilizer treatment. While during the extreme dry weather of the past season, fertilizer trials in general did not show up well, some striking differences were noticed between fertilized and unfertilized fields of red clover. Areas receiving both manure and rock phosphate as a top dressing in addition to the lime were decidedly superior to those which received lime only.

Alfalfa Increases in Importance on Wisconsin Farms

SINCE WISCONSIN has become the leading dairy state, the need for home-grown feeds that will make a suitable ration for dairy cattle has become increasingly important. It has been clearly demonstrated in certain sections that much can be done to reduce our annual feed bill by the growing of certain crops which heretofore have not been very prominent in our agricultural system. Of

these, alfalfa is undoubtedly first in importance and it has been shown by the use of proper cultural practices that this crop can be grown in most parts of the state in a very satisfactory way.

So far, only about 150,000 of the 2,800,000 acres of Wisconsin land which are in tame hay are given over to the growing of clover and alfalfa; timothy and mixed hay still make up by far the largest part of

FIG. 8.—ALFALFA CAN PENETRATE THE HEAVY SUBSOIL UNDERLYING COLBY SILT LOAM

These roots are from a third year alfalfa field at the Marshfield Branch Station and measure nearly 7 feet.

the crop. In many of the older sections soils are becoming deficient in lime, and it is becoming more and more difficult to grow the ordinary clovers. Information, gathered as the result of experimental work, shows that alfalfa is one of the safest and most profitable hay crops that can be grown in the older farming areas of the state.

Alfalfa Succeeds Where Clover Fails. Observations at this station indicate that alfalfa seedings survive drouth conditions better than

those of clover and timothy. In May and June of 1923, when the rainfall was 36 per cent below normal at Madison, excellent results were obtained with alfalfa, whereas it was difficult to get a satisfactory stand of timothy and clovers in this section. The vigorous root system and deep soil penetration of the alfalfa give this crop a peculiar advantage over the more shallow rooted hay crops in times of drouth.

Factors in Alfalfa Success. Growers of alfalfa are coming to realize that lime inoculation, good drainage, and reasonable fertility should be characteristic of the soil on which they expect to make the crop a success. Hardy seed and the use of early removed nurse crops are also essential. Winterkilling can be largely overcome by the use of hardy varieties and the avoidance of late fall cuttings. With the establishment of a two-crop cutting system, the crop usually goes into the winter with sufficient protection and reserve strength to survive even exceedingly severe climatic conditions.

More Hay From Two Crops Than From Three. That early cuttings weaken alfalfa, thin the stand, and permit weed and blue grass encroachments is evident in the third year of the cutting trials on the Station Farms at Madison. In 1920 plots of Grimm, imported Turkestan, and common Kansas-grown seed were sown, and a series of plots of each variety were cut at the following stages: Bud state (just before blossoming), tenth bloom or early blossom period, and full bloom. Three crops were taken annually from the bud and early bloom plots, while only two were taken from the full-bloom plots. In the 1923 season the early cut plots showed much weed and blue grass infestation which resulted in a thin stand and slow growth, while the full bloom plots were thick, vigorous, and practically free from weeds. The three-year average of these trials is as follows:

Bud stage	3 cuts	1.8	tons	an	acre
Tenth bloom	3 cuts	2.7	"	"	"
Full bloom	2 cuts	3.5	"	"	"

While the quality of the hay, especially the first crop, is not so good in the full bloom period as in the earlier stages, there is a difference in yield of nearly a ton in favor of the later cutting. In the first crop of one-year-old alfalfa or in the second cutting for the year, hay cut in full bloom is usually of satisfactory quality. Where the largest yields and the greatest permanence of stand are desired, the best guide to follow in cutting alfalfa is to cut only two crops a year and at as late a stage as possible without getting the hay too coarse.

Late Summer Seeding Gives Low Yields. On experimental plots which had previously been cultivated to kill the weeds, seedings of alfalfa were made on July 17 and on August 18 in order to determine whether seeding at these dates would produce satisfactory stands. The results of the trial indicate that, while a perfect stand may be obtained from the July seeding and sufficient growth made in the fall to withstand the winter, the probability of obtaining good results from the August seeding is small. In this particular trial the late seeding suffered an estimated loss of 50 per cent through winterkilling besides

being slow in growth and permitting heavy weed encroachments during the summer. The July seeded plot yielded 1.3 tons per acre, while that seeded in August yielded only .66 ton.

In these plots seeded in August, the alfalfa made less than three inches of fall growth. One-half of the area was covered with a thin coating of straw in November, the ground had frozen slightly, and in it winterkilling was hardly noticeable. While a good stand was obtained, the growth was slow and the yield was low the following season. It is interesting to note that the covered portion of the plot yielded 1.2 tons of hay per acre, as compared with the .66 ton for the uncovered portion. On account of the dry weather the second growth on this plot did not warrant cutting.

This indicates that, on many fields of alfalfa which are sown in August and because of climatic conditions make but a scant fall growth, an application of straw or evenly distributed barnyard manure may help to prevent the winterkilling of the seedlings. But, in general, late August seeding is not advisable in Wisconsin, because our seasons seldom permit sufficient top growth for winter protection and for enough root development to provide for vigorous growth and large yields of hay the following year. Seedings before the first week in August are usually much safer than later ones.

FIG. 9.—ROOT SYSTEMS OF DIFFERENT CLOVER SPECIES VARY

Left to right: (1) Hubam sweet clover seeded alone; (2) biennial sweet seeded alone; (3) Hubam sweet clover seeded in winter wheat; (4) biennial sweet clover seeded in winter wheat; (5) common red clover seeded in winter wheat. Note the difference between the roots of the Hubam and the biennial sweet clover.

Home Grown Alfalfa Seed for Wisconsin

MORE AND MORE Wisconsin is coming to produce at least a portion of her own alfalfa seed. For several years this has been increasing and it is estimated that the 1923 crop of alfalfa seed in Wisconsin will be around 3,000 bushels. Much of this is of the Grimm variety.

The second crop is generally taken for seed, and if there is dry weather during the blossoming period, yields of from two to four bushels an acre have been obtained. A 25-acre field of Grimm on the Cornfalfa Farms at Waukesha produced 71 bushels of seed. Seven acres grown by Neil Quotsoe, of De Pere, produced 45 bushels. Though these yields are quite exceptional, it is apparent that growing alfalfa seed at present prices can be made profitable.

Whenever dry weather prevents a big crop of hay, conditions are usually good for seed production. If heavy rains occur and the alfalfa blooms sparsely, it is best to cut it for hay, for unless the weather is dry the seed crop is likely to be disappointing. In handling the crop for seed, it is treated exactly like red clover.

Sweet Clover As a Forage Crop

SWEET CLOVER as a pasture crop is being emphasized in Wisconsin. Trials over a period of years have shown that sweet clover will produce excellent pastures and will probably carry stock through the dry period of the summer better than many other pasture plants. It is likely that this crop will be used more and more by the dairy farmers who find it difficult to provide succulent forage for their herds in late summer or early fall.

On the natural lime soils of the state this crop grows without difficulty. In the northern and western sections, however, good catches are not obtained as a rule unless the land is limed. For this reason the expansion of this crop throughout the state has not been as rapid as it would otherwise be. Experimental work to determine the best conditions under which to grow sweet clover is being continued by H. W. Albertz (Agronomy).

Hubam Clover. The annual or Hubam sweet clover which has been strongly advocated in some states has been tried in Wisconsin for several years. The experimental work so far indicates that it is inferior to the biennial white-blossomed sweet clover which is commonly grown. Results also show that, aside from its value as a honey plant and as a seed crop, while the price remains fairly high, this clover does not have a prominent place in Wisconsin's farming system. The work shows, too, that while these plants make a very rank growth when grown in cultivated rows, they do not successfully compete with weeds or other plants when sown alone or with nurse crops. In this particular, the biennial white-blossomed sweet clover has been found far more satisfactory.

Canadian Albotrae Sweet Clover. The Canadian Albotrae or yellow sweet clover which was obtained several years ago by R. A. Moore (Agronomy) has proven very satisfactory. This plant is fine stemmed and has an abundance of leaves, which makes it more desirable for hay than the ordinary biennial white-blossomed sweet clover. Trials indicate that this crop produces an excellent quality of hay, and, when grown for seed, yields as much as 10 or 12 bushels per acre. Enough seed has been produced for its general dissemination the coming year, and it is felt that when once the crop becomes widespread it will be largely used for pasture and seed.

FIG. 10.—HUBAM IS TALLER BUT LESS BUSHY THAN COMMON SWEET CLOVERS

Hubam sweet clover will grow tall and vigorous in cultivated rows but has failed to compete with the biennial varieties as a field crop. The tall row in the illustration is Hubam and the other three rows are biennial sweet clover.

Soybeans Increasing in Wisconsin

ALTHOUGH the soybean has come into general use on our farms, it is only in recent years that it has been widely adopted in Wisconsin agriculture. This plant is especially adapted to the light sandy soils of the northern and central parts of the state, and its largest acreage may be found there. Over 18,000 acres of this crop were grown for seed or hay in 1922 and probably several times that amount was grown in mixtures with other crops. For the year 1923 there has undoubtedly been a large increase.

Several new varieties have been recently introduced and work was undertaken by the departments of Agronomy and Genetics to study the problem of mottled seed which has been appearing in some of the pure line selections.

New Varieties for the North. According to E. J. Delwiche (Agronomy) a new soybean, pedigree No. 19507 or Mandarin, which has been developed at the northern branch stations is probably the best strain that has been bred up in recent years. This new yellow seeded strain has the advantages of rapid growth and early maturity. The fact that it grows more upright than most beans makes it possible to harvest with a binder without much waste. It is a heavier yielder of seed and gives promise of becoming one of the leading varieties in central and northern Wisconsin. Some seed will be available for dissemination in 1924.

Other pure line strains of soybeans derived from such parent stock as the Manchu, Ito San, and Black Eyebrow are on test at the Spooner Branch Station and at Marshfield. These give promise of displacing the parent stock by virtue of their superior qualities.

A new problem has arisen this last year in that some of the pure line selections have shown a mottling of the seed coat that has caused much loss to growers of certified seed. It is a question whether this is due to cross fertilization or to environment.

FIG. 11—SOYBEANS "HOODED" FOR SELF-POLLINATION

In this way self-pollination is assured without danger of crossing. Of late "mottling" of many registered seed stocks has been a serious problem.

Emergency Hay Crops Useful

EVERY YEAR many Wisconsin farmers find it necessary to bolster up their feed supply by seeding emergency hay crops. Experiments over a number of years have shown that such mixtures as oats and field peas, Sudan grass and soybeans—or Sudan grass and soybeans alone—can be used to good advantage. During the past year, trials with emergency hay crops were continued by G. B. Mortimer (Agronomy) to determine more definitely the relative value of these various crops and mixtures.

FIG. 12—SUDAN GRASS AND SOYBEANS ARE EXCELLENT EMERGENCY HAY

This combination yielded between three and four tons of hay per acre at the cutting stage. One-third of the total weight was soybean hay.

Several varieties of soybeans were sown with Sudan grass for late seeded emergency hay crop combinations. While all of them gave satisfactory yields, the Hollybrook varieties and the Medium Green retained their lower leaves up to the cutting period better than the Manchu variety. In trials at the Spooner Branch Station, Sudan grass and soybeans separately yielded 2.5 tons each per acre while a mixture of the two yielded 2.4 tons.

Yields on other plots showed that about 3.5 tons of air-dried hay were produced per acre and about one-third of the crop was soybean hay. From the standpoint of the dairyman, it is especially desirable to interpret these yields in digestible protein as well as in total gross tonnage. When the yields were computed according to the Henry-Morrison standards, the introduction of the soybeans yielding one-third of the hay increased the digestible protein yield per acre of the mixed crop over Sudan grass about 66 per cent. It was also found that, when soybeans and Sudan grass are grown together as a hay mixture, the hay is more readily cured than soybeans alone because of the better circulations of air made possible in the hay cocks or windrows by the Sudan grass stems. This combination has the added advantage of producing a larger yield of hay per acre than the soybeans alone; and upon the sandy sections of the state, this is very desirable. The most satisfactory rate of seeding this mixed hay crop seems to be about 10 pounds of Sudan grass and from 1 bushel to 1.5 bushels of soybeans per acre.

Other Soybean Trials. Soybeans were tested out with field peas, oats, and foxtail millet as possible emergency hay combinations. None of these were found satisfactory, however, though the soybean-foxtail-millet combination yielded a fair crop.

Sudan Grass as a Seed Crop. Enormous quantities of Sudan grass were used by Wisconsin farmers in recent years. Much of this seed has been imported from other states but trials during the past year indicate that yields of 900 pounds or more of uncleaned seed and about 650 pounds of cleaned seed can be produced per acre. A development of a Sudan grass seed industry which will supply the needs of our local trade is entirely probable, as the seed grown in Wisconsin so far has proven to be of excellent quality.

Drilling Grain or Broadcasting?

AN ACTUAL TEST as to the merits of drilling seed grains over the older and more common method of broadcasting was conducted by B. D. Leith (Agronomy). Results show that on the Miami silt loam there is no appreciable difference between these two methods.

In trials conducted over nine years on the Hill Farm the yields of broadcasted grain are equal to those of the drilled grain. This is especially true when the crops are planted under favorable growing conditions.

In a sandy soil where the seed may not work in readily and where there is more danger of drying out, the drill is a better implement than a broadcast seeder. Furthermore, when winter grains are planted late in the fall, the kernels dropped into the bottom of the drilled furrow where the ground is moist and the conditions more uniform have a better chance of growing and surviving the winter than broadcasted grains which are much more likely to remain near the surface.

The claim has often been made that when grain is sown by means of a drill, less seed is required than in broadcasting. Experiments, however, do not bear out this statement and indicate that equally good results are obtained by using the same amount of seed broadcasted as when drilled.

Demand for Cold Resistant Corn Increases

FROM MOST of the tier of states along the Canadian border as well as from Canadian provinces, calls continue to come for Wisconsin cold resistant corn. From the time of its early development in ice box germination tests by B. D. Leith, a widespread interest has been shown in this strain. Its general dissemination shows that it is meeting a distinct need in the northern sections.

The fact that this corn is more resistant to low temperature commonly makes planting possible at an earlier date; and as much as a week or ten days may be gained in this way. Frosts in the early part of the growing season which are usually disastrous to ordinary corn

FIG. 13—COLD-RESISTANT CORN WITHSTANDS NORTHERN WISCONSIN CLIMATE

R. A. Moore, inspecting a field of cold-resistant corn on July 29th in Florence county. This three-acre field filled a 50-ton silo and there was some left over. An insistent call for this seed continues to come from many northern states.

have been less serious with the cold resistant variety and, when it is frosted, recovery has been more rapid than with other varieties. Its early maturity usually enables it to escape the autumn frosts.

Improved Strains of Sweet Corn Give Good Results

IMPROVED strains of sweet corn developed at the Wisconsin Experiment Station are finding favor with Wisconsin canners. This work has been continued the past year by E. D. Holden (Agronomy). Promoting the use of home-grown seed by the canning factories and improvement by selection and breeding the best varieties are features of the work. Since these studies were begun several

FIG. 14.—CANNING SWEET CORN IS A GROWING WISCONSIN INDUSTRY

This factory is curing its own supply of Golden Bantam seed.

years ago, the number of companies raising their own seed in this state has doubled, and it has been found that the home-grown seed produces a larger yield and more profitable crops.

There are two advantages in using home-grown seed: (1) Even well-bred varieties lose greatly in productiveness when grown in unaccustomed regions and under different conditions. For this reason strains which are grown for several years in the locality where they are to be used have an advantage over even highly bred strains brought in from a distance. (2) Growing their own seed enables the canners to select only good ears which show the desirable characteristics and, by repeated selections, in a few years they can bring their strains to the highest productivity.

Breeding and selection has been stressed by certain canners so that they now have excellent types of such popular varieties as the Early Evergreen and Country Gentleman. Because of its excellent qualities, the Golden Bantam variety has been the object of much experimentation. Usually this corn is so low in yield that it is unprofitable, but the demand for fancy corn makes it desirable to improve this variety and work on it will be continued.

Wisconsin Flax Growing May Develop

THROUGH the decrease of the flax acreage in the western states, the oil industry has seemingly begun to suffer from a shortage of flax seed. To determine whether the crop could be grown to advantage on Wisconsin farms, A. H. Wright (Agronomy), in cooperation with the Flax Development Committee of the American Linseed Manufacturers' Association, has undertaken a series of trials. It is possible that a cash crop of considerable value may be developed.

The work done in 1923 indicates that flax can be successfully grown

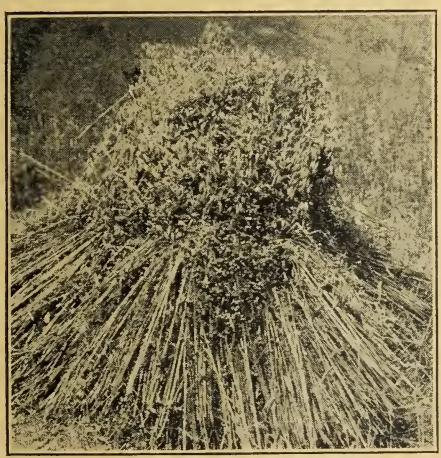


FIG. 15—FLAX AND OATS MAKE A GOOD GRAIN MIXTURE

These two crops together are easier to handle than flax alone. A fanning mill separates them readily after threshing.

with several of our small grain crops. A number of trials were conducted with mixtures of flax and oats, flax and barley, and flax and wheat. Of these, spring wheat and oats were found to be the most satisfactory grains with which to produce flax as a cash crop. Barley was found less satisfactory because it matures so much earlier than the flax as to make it impracticable. The late varieties of oats are more satisfactory than the early ones with which are encountered the same difficulties as with barley. Of the numerous trials made in twelve sections of Wisconsin, it appears that the most promising combinations of growing flax in mixed grain crops are:

(1) Flax 28 pounds—oats 48 pounds
(2) Flax 28 pounds—oats 40 pounds.
(3) Flax 35 pounds—oats 32 pounds.

The advantages of growing a mixture of oats and flax are: (1) Flax is a good cash crop and cannot generally be grown on the old lands of Wisconsin on account of weeds, a problem which is overcome when mixed with oats; (2) flax should normally be sown early, and when grown as a mixture with oats, early planting is assured; (3) a mixture of flax and oats is easily harvested and threshed, whereas flax alone is often exceedingly difficult to handle; and (4) the two crops can readily be separated from each other after threshing by means of an ordinary fanning mill.

Flax on Marsh Land. The result of three years of experimentation indicates that the flax will produce a satisfactory crop for the first year on fresh sod marshes, provided the land is properly drained and the sod covering complete. Drained peats which have little or no sod covering are not suitable for seed flax. Peat soils which have been previously cultivated are usually unsatisfactory for seed flax by reason of weed infestation to the extent that this crop cannot be grown to advantage. Flax grown on such land is usually weedy and of low quality.

Hemp Situation Unsatisfactory

BECAUSE of adverse economic conditions, the hemp industry has declined steadily for the last three years. The acreage in Wisconsin has been reduced from 8,000 to approximately 900 and only a few mills in the state are now in operation. The entire acreage in the United States has been reduced from 41,000 in 1917 to 1,700 this year. This is primarily due to foreign competition, principally from Italy, and an insufficient tariff to prevent ruinous competition. However, it is desirable to know under what conditions this crop can best be grown as this information may be needed when conditions are again normal.

Hemp Production on Marsh Soils Possible. For several years efforts have been made to grow hemp on the various marshes of the state, and it has been shown that these soils differ considerably in their response. Numerous plots tried on the University marsh indicate that fertilizer treatments are usually not helpful in producing a satisfactory fiber on this soil. On the Horicon marsh near Waupun considerable increase in growth was attained by fertilizers especially those complete fertilizers (including nitrogen, phosphorus, and potassium). It appears that a satisfactory hemp can be grown on this marsh by the use of a limited amount of fertilizer containing both potash and phosphates. Seemingly favorable results were also obtained in the marshes at Coddington, though no mill tests have as yet been made on this material to determine the quality of its fiber.

Marketing Pedigree Seeds

After outstanding varieties of pedigree seeds and grains have been produced, it is important that they be widely distributed. In order to promote a more extended use of high quality seeds in the state, the Wisconsin Experiment Association and the department of Agronomy have for many years been rendering a special service to farmers who had seed for sale. Marketing seed as effectively as possible may be made a considerable item in the success of the business.

Besides furnishing the members of the Experiment Association with shipping tags, envelopes, letter heads, and specially trademarked bags for their product, special marketing booths were also set up at the various shows and expositions in the state during the past year. Seeds were shown in bulk lots and offered for sale. These features attracted wide attention and were a considerable stimulus to grain growers. It is quite as important that the experimental results find their way into actual use as it is that they be actually developed.

FIG. 16—MARKETING BOOTH AT STATE GRAIN SHOW, JANUARY, 1923

Displays such as this can be made a distinct educational factor in agriculture and a stimulus to the pure-bred seed industry.

Winter Wheat Versus Spring Wheat

While the total wheat area in Wisconsin has been declining for several years, the acreage of winter wheat grown in the state has in the last few years remained fairly constant. Winter wheat is in greater favor with the farmers of Wisconsin than spring wheat and about 95,000 acres of winter wheat were grown in the state last year.

Carrying the crop through the winter without winterkilling is one of the chief problems of the wheat grower. B. D. Leith has experi-

mented to determine what factors influence winterkilling. His work shows, on the basis of five-year averages, that higher yields have been obtained when the crop was sown during the latter part of September. Some excellent crops have been grown by seeding in October or early September and even late in August; but, as a general rule, wheat seeded along in October does not make sufficient growth to survive the winter in good condition and that sown before the middle of September makes so rank a growth as to multiply many times the chances of winter injury. Seasonal conditions, of course, determine very largely the success obtained from a seeding on any particular date.

Rate of Seeding Winter Wheat. From a series of trials over five years, Mr. Leith found 1.5 bushels per acre the most satisfactory rate for the seeding of winter wheat. Slight gains have been obtained by seeding as high as two bushels per acre, but these are seldom sufficient to warrant the higher rate of seeding. When the grain is sown thickly, stooling is largely prevented. Where there is a lighter rate of seeding or where a part of the plants have been eliminated by winterkilling, sufficient stooling occurs to take up practically all of the unused space.

Pedigree Varieties Yield Best. The pedigree No. 2 (Turkey Red) winter wheat is one of the most satisfactory strains so far developed. Its average yield for 13 consecutive years was 34.2 bushels per acre, and it excelled Kanred, one of its competitors, in four years out of five.

Companion Crops With Corn

IN ORDER TO determine which crop, if any, can be profitably sown with corn at the time of last cultivation so as to provide a fall pasture crop on Wisconsin farms, H. W. Albertz carried on trials during the past year.

It appears that such crops as winter vetch, sweet clover, soybeans, alfalfa, rape, and field peas may be sown in corn to advantage at the time of the last cultivation, which is usually early in July. A favorable season with uniform distribution of rainfall is, of course, essential for maximum results. The experiments indicate that where corn is grown for silage it suffers very little from the competition of such crops, for the secondary crops usually make their greatest growth after the corn is cut. Good quantities of pasturage may be so produced in favorable seasons.

Soybeans in Corn. Experimental work was done to determine the best rate of planting soybeans in corn and also which varieties are best suited to combine with corn for silage. It appears that appreciable gains may be obtained if heavy plantings of soybeans are incorporated with the corn. Besides the additional amount of silage provided, there is the advantage of having an increased amount of protein in the silage. On the lighter soils of the state combinations of this sort may be very economical in providing silage of high quality on dairy farms.

Breeding Disease-Free Barley

STUDIES to determine whether a stock of pedigreed barley, free from infection with the bacterial stripes disease, can be developed were continued this year. These were started in 1919 in cooperation with A. G. Johnson, of the U. S. Bureau of Plant Industry. No evidence of the disease was found during the present season. The small quantity of seed harvested this year will be planted in increased plots next year to propagate this disease-free strain. It will take several years before this type is sufficiently abundant for general distribution.

Cost of Producing Silage Studied

TRIALS with different kinds of silage and other crops grown to furnish succulent winter feed in the north have been conducted at the Ashland Branch Station for a number of years. Yields during the past season were excellent and the labor cost of production per ton of silage was relatively low, as shown by E. J. Delwiche in the following table:

TABLE V—COST OF PRODUCING VARIOUS SUCCULENT CROPS, ASHLAND BRANCH STATION—1923

Crop	Tons per acre	Labor cost per acre	Labor cost per ton
Silage corn	12.3	$40.00	$3.27
Sunflower	17.7	42.50	2.40
Corn and sunflower	15.0	40.50	2.70

That rutabagas make a satisfactory crop for producing a large quantity of succulent winter feed is shown by trials extending over a six-year period. During that time this crop has averaged 13.35 tons per acre at labor costs of $3.32 per ton. In this average is included a low yield made during the past year due to adverse weather conditions.

New Varieties of Oats Continue Successful

IN ORDER to provide new and higher yielding strains of oats, work has been done with a large number of varieties. New strains have been developed, and experimental work this year shows that some of them are retaining the excellent qualities for which they were bred.

Forward Oats a Good Yielder. At the Ashland Branch Station "Forward," a new high-yielding variety of oats, has attained a nine-year average of 57.9 bushels per acre, which exceeds its nearest competitor by 4.7 bushels. During the past year, this oat was also one of the leaders on the light soils of the Spooner Station.

White Cross Oats, a Leading Early Variety. During the past year White Cross oats was superior in yield at Madison as an early variety and produced 52 bushels per acre. Some of the late varieties such as pedigree No. 1 are giving larger yields. Pedigree No. 1 oats averaged 58 bushels per acre on the test plots during the past year.

Horal, a Successful Canning Pea

THAT THE Horal pea is a very satisfactory canning variety has been demonstrated by another year of trials on the experiment stations, as well as by tests by one of Wisconsin's leading canners. This variety has been developed on the northern branch stations and may mean much to upper Wisconsin. The quality of the Horal pea is high and the flavor very good. This, together with the uniform green color, tender skin, and high percentages of small sizes, makes the strain an excellent one for canning.

The Wisconsin Pea Packers' Association has recognized the value of the new pea and is planning to disseminate the variety. They purchased the entire stock of seed that could be spared from the Experiment Station and now propose to grow it under their control and under the supervision of the Experiment Station for purposes of dissemination. In this way the stock will be kept pure and the seed can be distributed at reasonable prices.

Though 1923 was a crucial year for the pea growers by virtue of the long period of hot dry weather in the growing season, the Horal peas survived remarkably well. Reports from the Ontario Agricultural College indicate also that it is resistant to root rot to a greater degree than are the standard canning varieties such as Alaska and Horsford, from which the Horal was produced.

It was thought at one time that, because the Horal pea does not grow rank and tall, it might be difficult to harvest, but results have shown that this is not the case. The erect growing habits and the profuseness of its tendrils make the variety rather one of the easiest to handle.

With additional canning factories being built in the Lake Superior region of the red clay soil of upper Wisconsin, the value of this industry in the northern counties assumes a new importance. The longer growing season of this section gives it a peculiar advantage in the industry, and canners appear to be ready to take advantage of that fact. A highly productive canning crop such as the pea which combines with it so excellent a livestock food as pea vine silage, is certain to become a distinct factor in the development of sections of upper Wisconsin.

Seed Pea Stock at Peninsular Branch Station. Tests were made with five new canning pea varieties in acre lots at the Peninsular branch station in Door County to find out whether or not it is feasible to grow seed peas in this region to supply the canneries of the state. Yields from 9.4 to 16.6 bushels per acre were secured. Early strains of Alaska were the most profitable.

Studies on Nature of Disease Resistance in Cereals

THE SEEDLING blight of wheat and other cereals, caused by *Gibberella saubinettii* has been shown by J. G. Dickson (Plant Pathology) to be especially well adapted to a critical study of the relation of environment to parasites and predisposition to disease. The reason is that the same parasite is able not only to attack a number of different host plants, but also that they vary greatly in their responses toward soil temperature.

This disease is manifest on both wheat and corn (1) by blighting before germination or before emergence, which results in a poor stand, and (2) by blighting after emergence from the soil which is evident by the yellowed and wilted seedlings. The invaded tissues in both hosts become reddish-brown to carmine red, depending upon environmental factors. The parasite in pure culture functions normally over a comparatively wide range of temperature, namely, from 37°F. to 90°F. (3°C. to 32°C.). The optimum temperature for spore germination, vegetative development, and spore formation is about 75°F. to 82°F. (24°C. to 28°C.).

The wheat plant functions best in all stages of its development at relatively low soil temperatures. While wheat germinates more rapidly at soil temperatures of 75°F. to 82°F. (24°C. to 28°C.), the germination is more uniform and stronger plants are produced at the lower soil temperatures—about 46°F. to 82°F. (8°C. to 28°C.). On the other hand, corn seedlings develop best at soil temperatures of 75°F. to 82°F. (24°C. to 28°C.). Uniformity of germination and stand diminish rapidly below 68°F. (20°C.), while at 53°F. (12°C.) and below, all growth processes are greatly retarded.

If soil temperature is a controlling factor in the development of seedling blight, is it primarily due to the influence of temperature on the host or parasite? If dependent upon the fungus, then blighting of wheat and corn alike should be more severe at the relatively high soil temperatures which favor development of the fungus; if upon the hosts, then the reaction of wheat should be different from that of corn.

The seedling blight of wheat develops only on the young plants growing at the higher soil temperatures. The plants grown in the greenhouse at 46°F. (8°C.) and in the field when the mean soil temperature is below 50°F. (10°C.) do not blight. Above 50°F. (10°C.) blighting appears and increases rapidly in severity with rising soil temperatures up to about 68°F. (20°C.) which is the maximum temperature for the production of seedling blight. Thus the temperature curve for the seedling blight of wheat seems to parallel closely that for the growth of the fungus. The suggestion therefore is that the blight is caused by the stimulating influence of the higher soil temperatures on the fungus. On the other hand, the experiments show that low soil temperatures favor wheat development at all stages of growth, whereas the high soil temperatures produce weak, abnormal plants. Therefore, consideration should be given to the relation of

soil temperature to disease development in corn, which is a relatively high temperature plant.

The seedling blight of corn develops on the seedlings growing at the low soil temperatures. At 46°F. (8°C.) where all the wheat plants remain disease free, all of the corn seedlings blight. The disease is severe at temperatures from 52°F. to 61°F. (12°C. to 16°C.) and milder at those from 61°F. to 74°F. (16°C. to 24°C.) at which it is checked entirely, only a few root lesions resulting. Thus at 74°F. (24°C.) and above, the parasite does not attack corn and yet at these soil temperatures the seedling blight of wheat is very severe. These results show that the dominant influence of soil temperature must be with the hosts rather than with the parasite. This is further shown by the soil moisture experiments.

Soil Moisture as a Factor. Lowering the soil moisture to a point where normal growth of the seedling is inhibited predisposes both

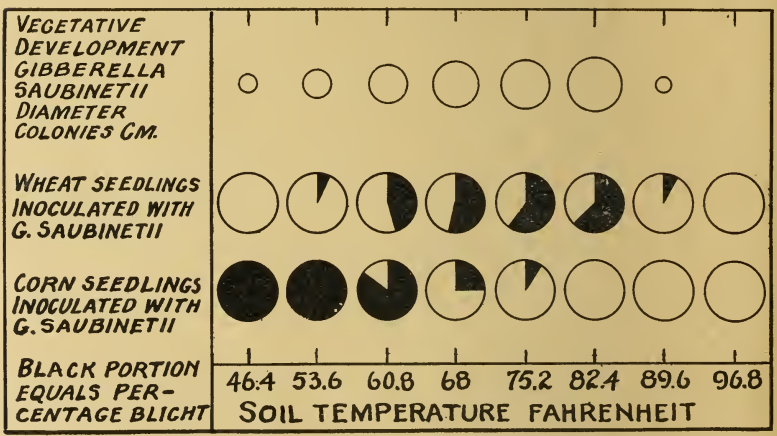


FIG. 17—TEMPERATURE IMPORTANT IN SEEDLING INFECTION

A graphic summary of the vegetative development of the seedling blight fungus in artificial culture and the comparative quantities of seedling blight of wheat and corn at different soil temperatures. The black portion of the circle shows the average percentage of blighted seedlings.

wheat and corn plants to attack by the seedling blight organism. The seedlings of both wheat and corn are blighted at all soil temperatures when the moisture content of the soil is reduced to 30 per cent of the moisture-holding capacity of the soil used. Control plants growing in sterilized soil are equally vigorous at the low and at the high soil moistures. In contrast, the plants growing in the disease-infested soil blight severely with low soil moisture at all soil temperatures. In other words, with low soil moisture, wheat seedlings growing at 46°F. (8°C.) blight severely and corn seedlings growing at 74°F. (24°C.) blight badly.

Conditions of temperature or moisture which are *unfavorable for the best development* of the cereal seedling seem to predispose it to attack by the fungus. The inference is that it may be due to some disturbance in the normal functioning of the plant. The influence of light also was determined, and the results further support the above inference. For example, at a soil temperature of 50°F. to 52°F. (10°C. to 12°C.) which is about the critical soil temperature for the production of blight, wheat seedlings grown with a low light intensity blight badly, whereas seedlings grown with a higher light intensity and with a longer period of illumination each day do not blight.

Histological Studies of Fungus Penetration. Studies on the character and extent of the fungus penetration of the host under these different environmental conditions show an important relation between host-tissue composition and disease development. For example, in the wheat seedlings growing at the low soil temperatures, the fungus threads slowly penetrate between the cell walls of the tissues, whereas, at the high soil temperatures, direct and rapid cell penetration occurs. On the other hand, in the corn seedlings growing at the low soil temperatures, direct penetration of the cell walls occurs, in contrast with a slow invasion between the cell walls of these tissues at the high soil temperatures. In both wheat and corn seedlings all gradations between these two types of penetration occur at the intervening soil temperatures.

These experiments indicate, further, that soil temperature and other environmental factors over periods of considerable time are more influential than brief exposures to extremes in determining predisposition to disease. Therefore, fungus penetration and disease development, or "blighting," probably are associated with the growth responses of the hosts. If this be true, the nature of disease resistance or disease susceptibility can best be determined by a study of the influence of environment upon the functions of the plant. The growth processes of the germinating wheat and corn seedlings is sufficiently different at the various soil temperatures to explain in a large part the difference in response of the two plants.

Chemical Studies of Hosts in Relation to Disease Development

AT THE LOW soil temperatures, the starch in the wheat endosperm is converted into soluble form (hydrolyzed) much more rapidly than the protein. At the end of seven days at 53°F. (12°C.), nearly all the starch from the lower flanks of the grain is changed. There is much sugar in the embryo, especially in the growing root. The storage protein in the endosperm is only just beginning to be changed and that at an extremely slow rate. There is a little peptone in the endosperm, but no amino acids can be detected. The cell walls of the root sheath (coleorhiza) are of cellulose and slightly lignified. The epidermis of the germinating shoot (coleoptile) is cutinized (hardened).

Under similar conditions of light and moisture, but at higher soil temperatures, 77°F. to 90°F. (25°C. to 32°C.), both starch and protein are converted into soluble form very rapidly. At the end of two days at 74°F. (24°C.), much of the starch of the endosperm is changed and also all of the protein from the lower half of the grain. The embryo contains some glucose, considerable dextrin, and many small starch grains in the cells of the root sheath and shoot. Other chemical substances occur. No cellulose is found in the cell walls of the root sheath, except in the walls of the root hairs. Neither is the epidermal wall of the developing shoot filled with woody material which makes an entrance into the soft interior tissues more possible.

This study of the cell walls of the germinating wheat embryo indicates that their chemical nature depends upon the kind of building materials available and their proportion one to another. In the very early stages of growth of the embryo this proportion depends largely upon the relative rate of change of the stored starch and protein into soluble form (hydrolysis) at any specific temperature. Because there is an abundance of sugar and extremely little available protein material in the embryo during the first ten or twelve days at the low soil temperatures, these young seedlings are practically high-carbohydrate plants, having thicker and more resistant cell walls, while at high temperatures the embryos are relatively high in protein, even at the end of twenty-four hours. There is more rapid vegetative growth, therefore, and less of the carbohydrate is used in the building, thickening, and hardening of the cell walls.

Quantitative chemical analyses agree with the micro-chemical study of the wheat seedling and further indicate decided differences in the physiology of the corn seedling. At the low temperatures, the wheat seedlings, separated from the endosperm, are high in sugars; at the low soil temperatures, the corn seedlings, separated from the endosperm, are low in sugars. Likewise the dextrins (the gums) in the corn seedling are lowest at the low temperatures.

The relatively high content of available carbohydrates in the wheat seedling at the low soil temperatures and the corn seedling at the high soil temperatures results in thickened cellulose walls offering resistance to fungus penetration. Undoubtedly this difference in chemical composition likewise supplies a different medium for fungus growth when penetration does occur.

Refined Control Methods for Fruit Disease

BY MEANS of the technical control described, G. W. Keitt and L. K. Jones (Plant Pathology) have been able to discover important steps in the relation of apple scab fungus to time of infestation of fruit and leaves.

Apple Scab. The apple scab fungus passes the winter in dead leaves on the ground. In the spring it develops spores which are shot into the air. Some of these lodge upon susceptible parts of the apple plant (leaves and developing fruit) causing infections which lead to the further spread of the disease.

Field and greenhouse studies of apple scab have shown that temperature and moisture cause important variations in (a) the development of the casual fungus, (b) the susceptibility of the host plant at critical periods, (c) the inception and development of the disease, and (d) the action of fungicides. Such studies can be definitely studied only under "controlled" environment.

Results already obtained have shown that in Wisconsin orchards the spores of the scab fungus mature and are discharged considerably earlier in the spring than was formerly supposed. Moisture and temperature appear to be the most important factors limiting their ripening and natural discharge. The addition of a "pre-pink" application of a suitable spray to the control programs previously used has successfully checked early infections and led to satisfactory control under conditions where the old programs failed.

Cherry Leaf-spot. Similar studies of cherry leaf-spot have shown that its development and control are also profoundly modified by environment. This fungus, like that of apple scab, passes the winter in the old leaves on the ground, and in the spring produces spores, which pass through the air to the cherry trees and start the disease. It has been found that, although the spores of the casual fungus are ordinarily matured before the blooming period, the early development of the disease in the Door County cherry section is so retarded by environmental conditions that it is unnecessary to apply the pre-blossom spray which was formerly considered an essential of standard orchard practice.

Relation of Environment to Health and Disease in Plants

EVERY FARMER knows that weather is of much importance in determining success or failure with his crops, even though many plant diseases are definitely known to be due to parasitic fungi of which the spores are the disease carriers. Right thinking about the cause and control of disease requires, however, not only a knowledge of the "germs" that cause infection, but a much more definite knowledge of the conditions under which they may infect.

This fact was very strikingly brought out by the Plant Pathological department early in the work with truck crops, such as cabbage and onions, at Racine. More recent studies have also proved it to be the key to a fuller understanding of the obscure potato and tobacco diseases. Studies on the relation of weather to plant diseases promise also to explain the reason for resistance or susceptibility of wheat and corn to root rot and, perhaps, throw new light upon the development and control of certain orchard diseases.

Weather Influences Cabbage Diseases. From the outset of the work of L. R. Jones (Plant Pathology) in southeastern Wisconsin on cabbage yellows, it has been evident that the severity of that disease depends directly on the weather. The disease is soil-borne, but even on the "sickest" soil where in a bad year the loss might be total, the next

season may yield a profitable crop. When resistant varieties were introduced, it was seen that even the best is not wholly immune and that under some conditions the disease resistance will partially "break down." The disease was worst in dry, hot midsummers. Was it drouth or heat or both together?

When seedling cabbage were grown in glass jars where the soil temperature was controlled by immersion at constant temperatures,

FIG. 18—DOING TWO SEASONS WORK IN ONE

By growing such biennial plants as cabbage in the greenhouse, it is possible to produce seed in about one year's time. This arrangement saves much time in experimental investigations. Picture shows production of "yellows" resistant cabbage seed.

J. C. Gilman and W. B. Tisdale found that the *higher the temperature* within the usual field range, *the worse the disease.* On the other hand, even in the "sickest" soil a low temperature so inhibits disease occurrence that healthy plants may be grown if the soil is kept continuously cool. The "critical" soil temperature is about 62°F. (17°C.), below which the cabbage plant escapes from the disease even if the parasite is abundant in the soil; above this point the disease becomes progressively worse.

Similar relations were demonstrated for the related wilt disease of the flax except that the critical temperature was found to be somewhat lower, about 56°F. (14°C.). Later investigations showed that, while soil moisture is also a factor and that the disease is worse in drier soils, soil moisture is a minor factor as compared with soil temperature.

Cold Favors Root Rot of Tobacco. With the tobacco diseases investigation made by James Johnson and R. E. Hartman, it was found that a low soil temperautre favored the disease. This serves to explain some puzzling observations regarding the behavior of the disease in the field. With old-infested tobacco soil, root rot may show up in the seed bed in the spring and continue to stunt the plants if the early summer continues cool; then upon the advent of high temperature about August 1, the field suddenly recovers and may even mature a profitable crop. A temperature condition which may therefore aid in the development of cabbage yellows will check the spread of tobacco root rot. In both cases, the crop would be healthy if no disease germs were present in the soil; but when the exciting cause—the specific germ—is present, environment, chiefly soil temperature, determines whether or not the disease develops.

Early Planting Favors Potato Canker. Similarly environmental influences affect the seriousness of two common potato maladies, stem canker and scab. With both of these troubles the germs are commonly carried on the seed and persist in the soil. But even when the germs are present, there are wide differences in the seriousness of the diseases. Studies made by B. L. Richards with controlled soil temperatures under greenhouse conditions have shown that stem canker is stimulated to its worst development by low temperature; so if the germs are present on the seed tubers, the young shoots may be wholly destroyed or become weak sterile plants. At high temperatures even with the canker organism present, the shoots escape uninjured. This explains why potatoes planted early while the soil is cool may suffer much worse than later plantings.

Temperature Affects Potato Scab. With potato scab, L. R. Jones and H. H. McKinney found that high temperature facilitates development of disease while low temperature lessens it. These foregoing illustrations all dealt primarily with root diseases, because in our earlier experimental work the soil conditions could be more readily controlled. It is also well known that the factors of air environment—moisture and temperature—exercise a similar controlling influence in the occurrence of diseases of the leaves and fruits of plants such as the common rusts, mildews, and scabs.

Absolute Control of Environmental Conditions

WEATHER may not be controlled in the open, but apparatus was developed that could be regulated so that not only soil, but air temperatures could be controlled as well as humidity. These have now been developed in greenhouse units so that plants in an entire house can be held within certain humidity and temperature limits. The temperature has been controlled to within 5°C. in four houses each 20x30 feet; humidity has been regulated only in the chambers. For most refined work, smaller culture chambers have been developed where the temperature control is perfect for all practical conditions.

Wisconsin Soil Temperature Tanks. These tanks consist of a water bath operating at a constant temperature in which is suspended a metal soil container. They are of standard size, 24x36x30 inches, and consist of a water-tight metal box placed in a wooden box of two inches larger dimensions in all directions. The space between the two boxes is filled with mineral wool, a nonconductor of heat. The top of the tank has a cover of metal and wood with the mineral wool between. Eight holes are cut in the cover to allow the eight soil cans to be suspended in the water bath. Each tank is equipped with a thermostat connected with a pony telegraph relay which acts as a switch to turn on and off the heating current of the Edison partial vacuum electrical heaters submerged in the tank. This equipment was used successfully in the study of tobacco root rot, cabbage yellows, onion smut, corn and wheat seedling blight, and others, all of which are diseases concerned with soil infesting parasites.

Air Temperature Control Chambers. The development of air chambers for temperature and humidity control necessitated a refrigeration machine and the rearrangement of two greenhouses into four compartments operated at different temperatures in which to install the control chambers. Each of these greenhouse compartments was equipped with separate thermostatic heating coils and in addition a large motor-driven blower operated by thermostatic control was installed in each of the two lower temperature houses. Thus in addition to regulation of the heat in each compartment, a rise in temperature in the two low temperature houses was safeguarded by employing a blower which takes in the cold air from the outside and circulates it inside the houses.

The control chambers placed within these greenhouses consisted of a cement base and a glass chamber above. The base was divided into a brine coil compartment, a heater compartment, and a third compartment in which the dampers were installed. The glass chamber, a cube of five feet, was constructed of double glass with a half-inch dead air space between. With the exception of the air inlet at the top and the air outlet vent at the bottom, this chamber has no equipment to occupy space needed for plant growth. Each chamber was equipped with

regulators for temperature and humidity operating dampers which control the air and moisture entering the chamber.

Both instruments were placed in the chamber where the air, after passing through the air tempering compartments and through the chamber, was forced over the instruments before being discharged. The thermostat, operating a mixing damper, allows larger or smaller quantities of the air driven over either the brine coils or the heaters to enter the chamber. The humidostat, in turn, operating a mixing damper, permits larger or smaller volumes of air to pass directly into the chamber or through the water spray in the humidifying compartment. A small electric blower connected with the heating and brine compartments by a six-inch pipe was installed outside of the base. This blower operates continuously insuring a constant, uniform flow of air over the coils through the mixing damper and humidifier into the chamber. Thus the air is constantly passing over the brine coils or through the electric heaters, or part both ways, depending upon the position of the mixing damper, and then through the humidifier into the chamber.

After a year's use of this equipment, the department is thoroughly satisfied that a marked advance has been made in perfecting the technique of closely controlled research. Any weather can be produced at will and its effect on plant life studied at close range. Definite results can now be gotten in a comparatively short time.

Potato Strains Fail to Resist Mosaic

TESTS MADE the past season with strains of Triumph potatoes, relatively free from mosaic disease after having been grown for two seasons in proximity to infected potatoes, reveal that the strains are not resistant to mosaic, but were merely free from the disease because they had been grown under a system of rigid roguing or isolation which had practically eliminated the mosaic disease from the particular strain. The demand for Wisconsin certified potato seed stock from out-of-the-state sources, however, makes it very desirable to continue this work in the hope of isolating resistant strains which will perhaps remain free from the mosaic disease.

Work on this subject will be continued by J. G. Milward and J. Johnson (Horticulture) and attempts will be made to obtain and preserve mosaic-free potato seed stock for dissemination in the commercial potato districts. Such work, if successful, will doubtless prove of value to the certified potato industry. This has in recent years acquired considerable prestige in Wisconsin, as is shown by the number of seed buyers from other parts of the country who annually visit Wisconsin, as well as by the extensive orders received for Wisconsin seed stock.

Nitrogen Fertilization Affects Off-Year Production

THAT THE dropping of fruit from trees which usually occurs early in the growing season is not due to lack of pollination, but rather to nutritional factors, is indicated by recent findings in determining the effects of pruning and nitrogen fertilization upon the off-year production of Wealthy apple trees conducted by R. H. Roberts (Horticulture).

The study so far shows that the so-called first drop of young fruit, which takes place shortly after the blossom stage, was very closely related to the vegetative condition of the spurs or branches upon which the blossoms were produced. Fertilization of the blossoms did not occur because of degenerate ovules, and these were the result of the influence of nutritional factors. The second drop of fruit which sometimes occurs after the petals fall is likewise due not to lack of pollination, as all of the young fruit have seeds in them which contain small embryos, but rather to the vegetative condition of the wood from which these blossoms fall. Similarly the third or so-called June dropping of fruit appeared also to be due to similar causes. Well-developed embryos were found in these young apples, and the dropping probably resulted from the nutritional condition of the trees. It appears that trees properly pruned and fertilized so that the bearing top will be in good vegetative condition will suffer less from loss of fruit by dropping, which has heretofore been attributed to other causes.

Does Light Affect the Fertilizer Requirements of Plants?

WHY DO some plants blossom less in the middle of the summer than in the spring or fall? Why do Rural New Yorker potatoes or Green Mountain potatoes blossom in one section of the state and not in another, or one year and not another? These and similar questions have interested scientific men a long time and, slowly but gradually, answers to some of them are coming from men engaged in plant research.

During the past year G. T. Nightingale (Horticulture), cooperating with E. J. Kraus (Applied Botany), has developed a number of facts of striking scientific interest, particularly on the relation of light to the growth and chemical composition of horticultural plants. While the work is yet incomplete, the following conclusions seem warranted:

1. Nitrates may be stored by the plant until the proper conditions arise for building up into other forms of nitrogen.

2. The presence of nitrates as such in the plant does not appear to affect materially the type of growth of the plant.

3. Conditions resulting in a decrease of insoluble nitrogen and a still greater proportional decrease in carbohydrates resulted in a relatively high proportion of insoluble nitrogen to carbohydrates, producing a strongly vegetative and unfruitful plant.

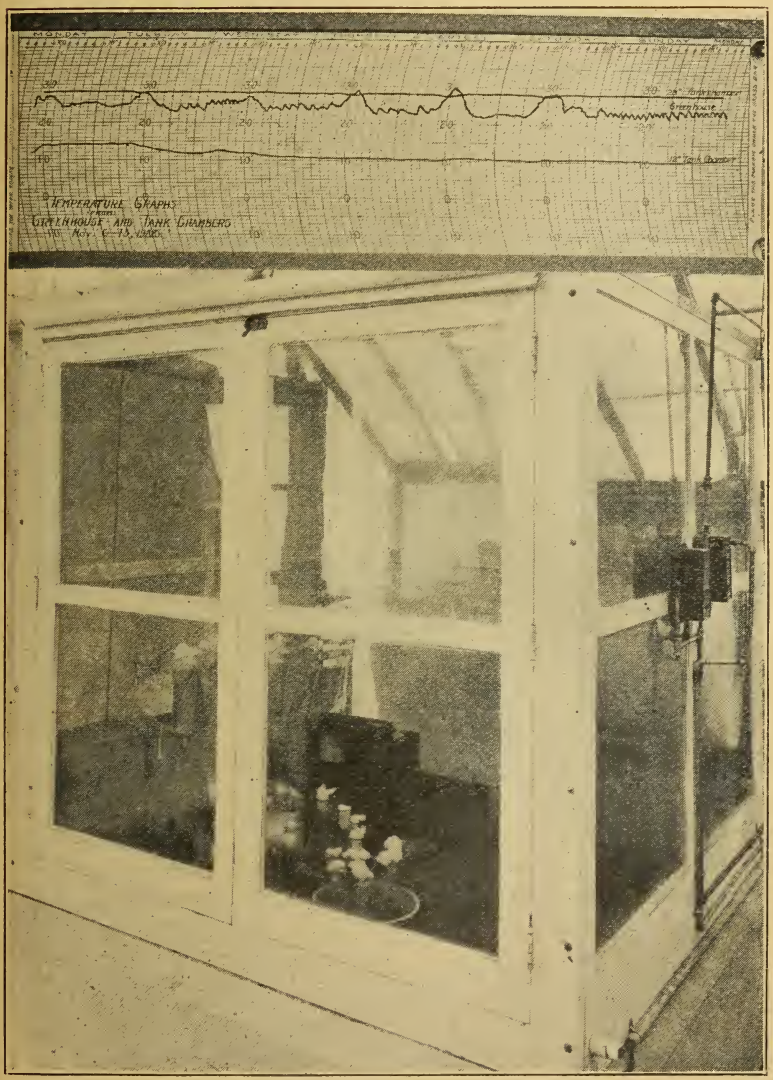


FIG. 19—A TEMPERATURE CONTROL CHAMBER WHERE WEATHER IS MADE TO ORDER

Plants are grown in these chambers under controlled temperature and relative humidity, thus making it possible to produce definite weather conditions and so determine their influence with exactness.

Inset shows graph of temperature maintained. Note its uniformity. Note the comparatively straight lines representing the temperature of the soil in two tanks operating at 12° and 28°C., respectively. Compare with the greenhouse temperature for the week.

4. Conditions favoring the formation of an abundance of insoluble nitrogen and at the same time an abundance of carbohydrates resulted in a vigorously vegetative and fruitful plant.

5. Conditions resulting in a decrease of available soluble nitrogen without simultaneously decreasing the carbohydrates supply resulted in a very high proportion of carbohydrates to insoluble nitrogen and produced a weakly vegetative and unfruitful plant.

6. It is possible that certain forms of soluble nitrogen may be as intimately associated with growth responses as are certain insoluble forms of nitrogen; no specific substances have been determined in this work.

7. In the case of tomatoes, light within the limits of a six-hour day did not appear markedly to limit the building up of nitrates to insoluble forms of nitrogen, providing there was present an available supply of carbohydrates.

FIG 20.—CURING TOBACCO UNDER CONTROLLED CONDITIONS

One of the reasons why there have not been more data on the curing of tobacco is the fact that it has been difficult to control atmospheric conditions. The new control chambers overcome this problem.

8. Buckwheat, soybeans, radish, and salvia of the varieties used, however, were limited in the building of nitrates to insoluble forms of nitrogen by a seven-hour day as it occurred in the greenhouse, even though there was present an available supply of carbohydrates.

9. A large decrease of carbohydrates in tomato plants already high in carbohydrates was apparently coupled with decomposition of insoluble nitrogen when this decrease was brought about by reduction in time of exposure of plants to light. Also, new growth was produced even though there was no external supply of nitrates available to the plant.

10. In the tomato, insoluble nitrogen was not decomposed to nitrates.

Curing Conditions Affect Quality of Tobacco

UNDER what conditions can tobacco be cured to best advantage? To throw more light upon the subject, experimental work has been done over four curing seasons by James Johnson (Horticulture).* Three experimental chambers in which the temperature and moisture of the air could be closely controlled were used, and valuable data on the rate of curing and the quality of leaf produced under different air conditions were compiled.

The results show that proper curing can only be obtained between temperatures of approximately 70°F. and 100°F. Below and above these temperatures abnormal processes occur. Usually the best cures

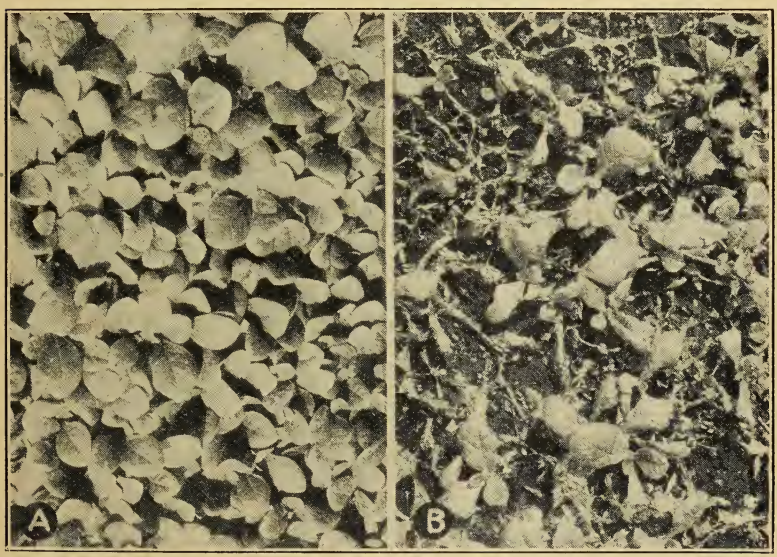


FIG. 21—WILDFIRE WORKS HAVOC IN TOBACCO SEED BEDS

(A) A seed bed before infection.
(B) A seed bed after infection

were obtained between 85°F. and 95°F. provided the humidity was kept sufficiently high. The humidity, however, varies with the temperature; and, in general, the higher the temperature the higher the relative humidity necessary for good curing of the leaf.

Results seem to be related more to the evaporating power of the air than to the relative humidity itself. It was found that, if the temperature is too low or the humidity too low, the leaf usually cures out with a greenish color, though this may be partly overcome by subsequent curing under good conditions. When the temperature is too high, the leaf is killed quickly and develops an olive green color. If, however,

*Cooperating with the United States Department of Agriculture.

the humidity is too high, damage occurs which is due in part to the development of fungi in the tissues which cause decay. Shed-burn seems to occur only under extremely moist conditions which do not permit evaporation of the moisture exhaled from the surface of the leaf. Stem-rot occurs at somewhat lower moisture conditions than shed-burn, but neither of these troubles prevail until the leaf tissues are about in the middle of the curing stage.

Much can be done to approach favorable curing conditions by the proper construction of sheds, hanging of the crop, and regulation of ventilation systems, combined with the use of some artificial heat during cold and moist weather, and possibly by the application of moisture to the ground in the shed during exceptionally dry periods so as to raise the humidity during dry periods.

Tobacco Wildfire Studied

THE WILDFIRE disease of tobacco which appeared in Wisconsin last year and has caused so much damage in other tobacco-growing sections has not become widespread in this state. This is largely because the weather during the past two seasons was unfavorable to the disease and because every effort was made by workers of the Experiment Station and the State Department of Agriculture to check the outbreak.

In order to be better prepared to cope with the disease if a serious outbreak should occur, experiments to control it have been undertaken by James Johnson in cooperation with the United States Department of Agriculture. This work has been planned mainly to determine where the germs of the disease live over winter and how they get into the seed bed in spring. Studies on dissemination of the disease, dusting and spraying of plant beds, and seed treatment have also been made.

The results so far show that the germs live over winter mostly on or in cured or dried tobacco leaves or refuse, and that other possible places of overwintering are probably of minor importance. Since experiments showed that about one hundred other plants (such as pepper, egg plant, tomato, potato, ground cherry, black night shade, Jimson weed, melon, pumpkin, cucumbers, peas, beans, clovers, as well as some grains and grasses) may also become infected with the disease, it is possible that it may live over winter in refuse other than that of tobacco origin and hence infect the tobacco seedling from various sources.

Since refuse from the curing shed is the main source of infection, it seems especially important on farms where wildfire has occurred to locate the seed bed a considerable distance away from the curing shed where pieces of infected leaves may less readily find their way into the beds. The sterilization of seed with mercuric chloride (corrosive sublimate—$HgCl_2$), which has been used by growers in other sections, has proved a failure in Wisconsin because of our method of sprouting seed.

The seed so treated failed to sprout "in bulk" and therefore cannot be used by Wisconsin farmers under their present system. A new method of seed sterilization which gives promise of being entirely satisfactory is now being developed. Dusting and spraying of seed beds, which has been recommended in some sections, has not been found satisfactory in Wisconsin because it does not give complete control of the disease in the seed bed; and unless the plants in the bed are

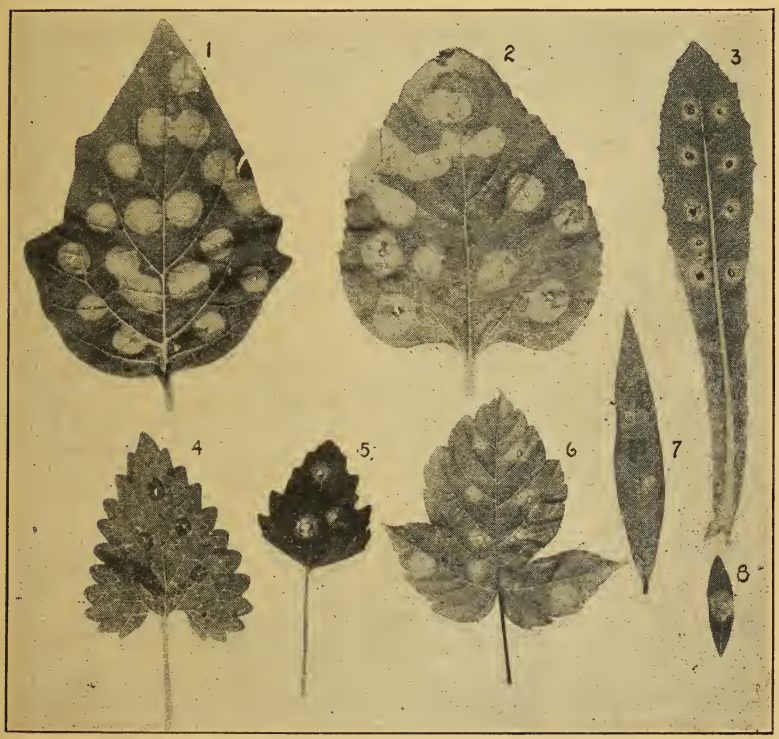


FIG. 22—WILDFIRE MAY ATTACK MANY DIFFERENT HOST PLANTS

1. Pokeweed
2. Sunflower
3. Prickly lettuce
4. Catnip
5. Lambsquarter
6. Maple
7. Ladysthumb
8. Chickweed

completely free from the disease, it is not safe to use them in the field. When the seed bed is not disease-free, plants should be obtained elsewhere for planting the crop. Observations so far indicate that methods of preventing infection are more satisfactory than any curative processes that have so far been advanced.

Cheap Formula Controls Grasshoppers

AFTER SERIOUS outbreaks of grasshoppers in certain sections of Wisconsin for several years in succession, research workers devised a formula for a cheap grasshopper bait which made control a relatively inexpensive matter.

The saving was made by using sawdust instead of bran in a formula that had been widely used prior to the Wisconsin outbreak. Sawdust may be had in many sections of Wisconsin practically without cost, and is satisfactory for this bait. Continued investigations the past year at the Peninsular Branch Station by C. L. Fluke (Economic Entomology)* indicate that effective sawdust bait can be made according to the Wisconsin formula at a cost of from 10 to 15 cents an acre for material, which is probably the cheapest effective bait. The formula of previous years has been cheapened by the omission of amyl acetate without materially lessening the attractiveness of the bait. The formula as now used is as follows:

Sawdust	85 lbs.
White arsenic	5 lbs.
Salt	5 lbs.
Water	to moisten
Shorts	15 lbs.

FIG. 23.—POISON BAIT DOES ITS WORK

Sprinkling different poisons on white cardboard enables the experimenter to test the relative efficiency of different baits.

The first three of these ingredients are mixed dry; then water is added and the shorts are later mixed in well. More water may be added if necessary.

Materials, such as amyl acetate, common salt, calcium chloride, molasses, soap, apple oil, lemons, and shorts, were tested to determine their value in adding attractiveness to the bait so as to render it more

*Cooperating with the Bureau of Entomology, United States Department of Agriculture.

effective. Of these, common salt was found to be about the best, and is considered essential to the sawdust bait. The various other materials tested seemed to give results in some cases, but were not effective enough to warrant the expense.

It is possible that the bait may be further cheapened by the substitution of crude leach, a by-product of the smelting industry, for the white arsenic. This material can be purchased at a price below that of good grades of arsenic, but additional trials will be necessary before it can be recommended.

Field tests with the poisoned bait under Messrs. Fluke and Granovsky have been so satisfactory that Door County farmers are reported as planning to treat all areas infected by grasshoppers during the next season.

Bees Need Winter Protection

BEES CAN BE wintered more satisfactorily when the hives are protected against low temperatures either by careful packing out of doors or by proper storage in bee cellars of fairly uniform temperature. This was demonstrated in previous work by H. F. Wilson and V. G. Milum (Economic Entomology).

Large losses occur in the state each year, because the suffering of the colonies from low temperatures during the winter months is so great that many fail to survive. The experiments of the past year indicate that when colonies were wintered in a heavy packing case with 10.5 inches of packing around the hives or in a bee cellar where the temperature is fairly uniform, they lived through the winter with relatively small losses and with but a small consumption of winter stores. Colonies wintered without packing last year required 31 pounds of stores from November 26 to April 12, whereas a colony in a heavy packing case required only 9¾ pounds.

TABLE VI—STORES REQUIRED WITH AND WITHOUT WINTER PACKING

Method of wintering	Amount of packing	Stores consumed
Without packing (No. 2)	No packing	31 lbs. November 26, 1922—April 12, 1923
Double walled hive (No. 1)	1½ inches	24 lbs. November 26, 1922—April 12, 1923
Double packing case (No. 5)	7 inches	14½ lbs. November 26, 1922—April 12, 1923
Heavy packing case (No. 4)	10½ inches	9¾ lbs. November 26, 1922—April 12, 1923
Bee cellar (Average of 12 colonies)		10⅓ lbs. December 6, 1922—April 10, 1923

The value of heavy packing for winter protection has been amply demonstrated in these trials. When a colony of bees is exposed to temperature below 57°F., it forms a compact cluster and maintains the temperatures within it by means of muscular activity. The temperature of the outer edge of the cluster is usually about 57°F., while the warmest part of the cluster varies from 70° to 90°F., depending upon the amount of protection given the colony and upon how low the outside temperature drops, the colder the outside temperature, the

higher the temperature maintained within the cluster. When the bees ar not required to produce a large amount of energy by muscular activity to maintain the proper cluster temperature during the winter months they not only survive the period of storage in much better condition than otherwise, but there is considerable saving in the stores required to carry them through the winter.

Colony Temperatures Affect Early Brood Rearing

IT IS IMPORTANT for a colony of bees to get an early start in the brood rearing season, and once they get under way it is also important that it be continued without interruption in order that the colony may be of sufficient strength and ready to harvest the honey crop in season. Recent work by Mr. Milum shows that brood rearing in the early spring takes place at temperatures much below 93°F.,

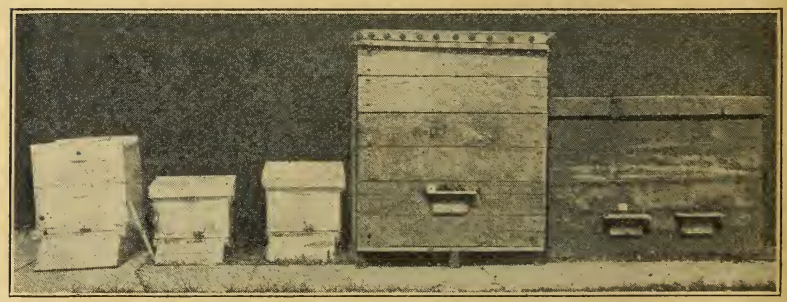


FIG. 24.—HEAVY PACKING PAYS IN WINTER STORAGE OF BEES

Bees survive the winter best when they are protected against low temperatures.
(Left to right)—No. 1 is a double walled hive, No. 2 a single walled hive, No. 3 is the colony removed from the bee cellar, No. 4 had 10½ inches of packing, and No. 5 had 7 inches of packing.

which has in the past been considered the brood rearing temperature. It has been found that brood rearing activities continue to points even below 90°F., but fluctuations below that point seem to retard the brood. High temperatures such as 96° or 97°F., which are sometimes attained later in the season are also undesirable because they increase the tendency of the colony to swarm.

Heavy insulation serves a good purpose in the brood rearing season, because it protects the colony from extremes of cold early in the spring and has a tendency to keep the temperature more uniform. Later in the season when the weather may be warmer, heavy insulation may cause the temperatures to be too high, due to lack of ventilation. Other factors, such as the general temperature, weather conditions, as well as the amount of sunlight, the size of the entrance, the amount of ventilation, and the size of the colony and its activities, may also influence to a certain degree the brood rearing activities within the hive.

Foulbrood Yields to Sodium Hypochlorite

SEVERAL preparations of sodium hypochlorite have been tested during the past season to determine its value in fighting American foulbrood. This disease has been prevalent in Wisconsin apiaries for twenty years or more, and considerable losses have resulted. The work so far conducted by H. F. Wilson seems to demonstrate conclusively that sodium hypochlorite is an effective remedy in destroying spores of the disease provided the treatment is used for a sufficient length of time. The use of the material, however, is limited because the cost of the chemicals is relatively high.

The experiments show that brood combs containing the larvae killed with American foulbrood can be sterilized if soaked in a concentrated solution of sodium hypochlorite for 24 hours and that both of the types of solution so far tested may be used to advantage in sterilizing hive bodies and hive parts from the diseased colony. This may be done by dipping or by spraying with the solution. It was also shown that spores in honey can be destroyed if very concentrated solutions are used. The cost of the chemicals in concentrated solutions, however, is so high as to make their use for this purpose doubtful except where applications can be made by spraying or a very short dipping process.

Control of Pea Aphis

SINCE Wisconsin is now producing over one-half of the canned peas of the nation and the industry is still expanding, there is naturally much interest in the success of the crop. Damage by the pea louse or pea aphis has been serious in some sections year after year and is present in moderate amounts every year. Studies in the control of this insect have been carried on during the past two seasons by J. E. Dudley (Economic Entomology).*

On account of the late wet spring the aphides did not become abundant until rather late during the past season. Extensive studies were made, however, by Mr. Dudley in the fields of the Columbus Canning Company. Slight infestations were noticed in pea and clover fields after April 22, but the insects did not become numerous until June 10 to 20 when a very marked increase occurred. Alsike clover, red clover, and alfalfa are usually the center of early infestation of the pea louse in cultivated fields. From these clover fields the aphides slowly spread to adjoining pea fields early in June, and it was observed that the number of aphides in the pea fields became appreciably less as the distance from the clover fields increased; but at a time of great infestation the insect seemed to be plentiful in all parts of the field.

Observations also showed that there are a large number of natural enemies which prey upon the pea aphis. Ladybird beetles and other enemies of the pea louse seem to increase rapidly when the insects become plentiful. In one field of alfalfa almost as many ladybird

* Cooperating with United States Department of Agriculture.

beetle adults were found as there were pea aphides, and in about ten days the aphides were practically wiped out. In order to test the effectiveness of these beetles where they were well established, a large number of them were caught and taken to a field near Waterloo which was heavily infested with the pea aphis. It was noted that after they were released the number of aphides in this part of the field decreased while there was a rapid increase elsewhere.

Birds Destroy Aphides. While birds in general have long been a good friend of the farmer, a particular case of their effectiveness came to the attention of the men working on the pea aphis during the past season. On June 29 a flock of about 40 red-winged blackbirds were noticed on the pea vines on a heavily infested field. Later three of these birds were shot, dissected, and examined, and their mouths, crops, and gizzards were found to be full of the pea lice. It was estimated that each bird contained the undigested portions of 250 aphides. The same results were noticed on other occasions, and it is very well established that millions of the insects are destroyed where flocks of birds are present to feed upon them.

FIG. 25.—THE APHIDOZER, A NEW MACHINE FOR COLLECTING PLANT LICE ON PEAS

This outfit, though but recently tried out, gives promise of meeting the pea louse problem. Inset shows a catch of 11 pounds of lice collected from 2½ acres.

Are Certain Varieties of Peas Immune to Aphis Attack? It has been claimed by growers and canners that certain varieties of "sweet" peas are immune from attack by the pea aphis, and men of science have been interested in verifying this observation. An opportunity to observe this supposed immunity came during the past season when a large field containing both Admirals and Advancers (both sweet varieties) was inspected on June 5. In the same field the aphides appeared to be more than 15 times as numerous on the Advancers as on the Admirals. Since both varieties were in about the same state of development, it appeared that the Admirals are less susceptible to attack than the Advancers. Further observations, however, will be needed to verify this result.

Control Measures Undertaken. Continuing the work of last year, applications of dust were tried after the aphides became sufficiently numerous to warrant the taking of machinery into the fields. The studies this past season were not only to determine the effectiveness of the insecticide, but also the most improved mechanical methods of application.

Several kinds of spraying booms were tried, one of which was an 18-foot triangular-shaped boom devised by the workers. This boom is all in one piece with a wide feed pipe as the center. The angle of the "Y" is very carefully constructed so as to give a gradual even curve of 90°. The boom is triangular in cross section; the bottom is open, forming a continuous slit for its entire length, the width of which can be easily controlled every foot and a half by winged nuts on bolts running through the two sides. Its distribution of dust is excellent and there was no trouble with clogging. It is believed that further trials with this boom will be highly satisfactory.

When a canvas trailer was attached to the boom, it helped to knock the aphides from the vines and thoroughly mixed the dust with the foliage. Where the canvas was weighted down with iron straps, it was more effective in knocking the aphides down to the ground where they were more readily killed by the insecticide.

In general the percentages of killed were not so high as was expected, but with strong dust and good weather conditions—i.e., high temperature and the absence of wind—kills from 70 to 85 per cent were obtained, though certain calcium cyanide dusts with a high cyanide content gave some trouble in the burning of the foliage.

The Aphidozer. In view of some discouraging results with dust and sprays, an attempt was made to devise a machine that would collect the aphides. E. M. Searls, of the United States Department of Agriculture, was assigned to this task and after considerable experimenting, a machine called an aphidozer was constructed. This effectively collected as high as 86 per cent of the aphides when the speed of the paddles was sufficient to brush the insects from the vines. Such a machine, if perfected, would have many advantages, as it requires little skill in operation and could be used in almost all weather except perhaps during a rain. Its operation would also be fairly inex-

pensive. Furthermore, the thousands of insect enemies which prey upon the pea aphis and are normally destroyed in efforts to control the aphis could be liberated very easily from this machine. A method to accomplish this has already been worked out.

Rain Destroys Young Pea Aphis. Canners often state that a heavy driving rain will clean up an infestation of pea aphis. On the night of June 7 a downpour lasting for over an hour made it possible to observe its results upon the pea aphis. It was found that, in a field of sweets which had been heavily infested with adults and all stages of nymphs, by the next morning the majority of the nymphs, especially those in the smaller stages, had disappeared from the vines, but the adults appeared to be as numerous as before. It was evident that the adults produced young at a rapid rate and that, while the rain may have destroyed large numbers of the younger insects, the check was at best a temporary one.

Dusting or Spraying for Leaf Hopper

THE COMPARATIVE costs of controlling insects by the use of nicotine dust, powdered bordeaux, and similar materials as contrasted with the more common applications of liquid sprays have been studied at the Culp Farm near Waupaca by Mr. Fluke in coperation with the U. S. Bureau of Entomology, Division of Truck Crop Insects. Results show no great difference in the relative costs of the two methods. In this trial the potato plots treated for leaf hopper by means of the liquid sprays outyielded slightly those treated by the dusting process. The cost of the dusting was slightly higher than that of the liquid sprays, though the method of applying the dust is simpler and more rapid.

Besides throwing some light upon the merits of the two types of treatment, the trials again demonstrated the value of using some method of controlling the leaf hopper in the potato section. Increased yields varying from 18 to 49 bushels per acre were obtained by its application.

Running Silage Cutters at High Speed Does Not Pay

GREATER economy results from running silage cutters at a lower speed, according to recent tests directed by F. W. Duffee (Agricultural Engineering), than that commonly recommended. This is especially true of the larger machines, for when two men were pitching off, the capacity of the machine was actually greater when the cutters were operated at a speed of from 550 to 600 revolutions per minute instead of the usual higher speed. At the same time a saving in the power requirements of about one-third was obtained when running a 14-inch machine at 550 revolutions instead of the rated 750.

With smaller machines probably the capacity is more often the limiting factor and more corn can be put through them by operating

at higher speed within the usual limit. But with these machines, as with the larger ones, the efficiency is much greater at slower speed.

The extreme fluctuation in these requirements at the higher speed was another important observation on the power requirements of high and low speeds. When operated at a lower speed, the usual hum and vibration of the machines was entirely absent and they were doing excellent work. It was also found that at slower speed the peak loads do not go nearly so high and the pull is more uniform and steady, which is desirable for both the cutter and the engine. When running more slowly, the feed table can be kept practically full and the upper rollers are constantly raised almost to the top.

The observations showed that properly designed machines will elevate silage by means of blowers to ordinary heights at speeds much below the usual recommendations. In two tests with 14-inch and 16-inch cutters, dry corn was elevated to a height of 100 feet at 662 and 670 R. P. M., respectively. This, however, cannot be achieved unless the machine is properly designed. See Table VII.

TABLE VII—RESULTS OBTAINED WITH CUTTERS RUN AT DIFFERENT SPEEDS

Name of cutter	Type	Size	Condition of corn	R.P.M.	Tons per hour	Av. net H.P.	H.P. hours per ton
1 Advance Rumely	Fly	15	Green	747	12.50	17.7	1.42
2 Advance Rumely	Fly	15	Green	694	13.03	18.2	1.396
4 Case	Fly	14	Green	762	11.77	16.88	1.434
5 Case	Fly	14	Green	662	11.66	13.90	1.192
6 Case	Fly	14	Green	545	12.70	12.30	.968
8 McCormick-Deering	Fly	14	Green	744	16.9	24.1	1.420
9 McCormick-Deering	Fly	14	Green	650	16.35	21.9	1.338
10 McCormick-Deering	Fly	14	Green	566	17.58	20.3	1.149
11 McCormick-Deering	Fly	14	Green	530	17.35	17.5	1.007
13 McCormick-Deering	Fly	11	Green	936	8.23	12.0	1.458
14 McCormick-Deering	Fly	11	Green	866	8.85	11.45	1.295
15 McCormick-Deering	Fly	11	Green	695	7.60	7.35	.967
16 McCormick-Deering	Fly	11	Green	613	7.24	6.10	.843
18 Papec (See Note 1)	Fly	16	Dry	670	22.1	32.4	1.46
19 Papec (See Note 2)	Fly	16	Dry	575	20.8	26.6	1.28
21 Rowell	Fly	13	Green	887	13.37	18.4	1.375
22 Rowell (See Note 3)	Fly	13	Green	767	11.55	10.15	.878

Note 1. Large capacity secured by having four men throwing off and three men feeding.

Note 2. High power requirement partly due to dry corn. Green corn test at this R. P. M. was 1.1 HP hours per ton, at 17.63 tons per hour.

Note 3. Elevated green corn at this R. P. M. but failed to elevate wilted corn. Fan design changed slightly and retest asked for too late to be given.

Soil and Quality Determine Life of Drain Tile

OUT OF Wisconsin's 189,295 farms, 52,228 contain land needing drainage, according to the census of 1920. Over 27 per cent of her farmers are interested in this vital subject. They have spent over $400,000 for tile drainage alone in 1923.

One of the primary purposes in tile drainage at the present time, especially in the older sections of the state, is to facilitate the cultivation of the land on a more efficient basis. Twenty acres of drained land producing a good crop may out-yield 40 acres of poorly drained land where the crop is a partial failure, and at the same time the cost of working the smaller area is considerably less. The removal of sink holes and the draining of sloughs in older fields will mean an increased efficiency in farm operation.

Studies on the durability of different kinds of tile under various soil conditions have been continued during the past year by E. R. Jones and O. R. Zeasman (Agricultural Engineering). These investigators, in cooperation with the United States Department of Agriculture, have found that, in general, comparatively poor concrete tile are standing up well in clay subsoils, but only the best show signs of permanence in peat. This deterioration in peat is less where dense walls with low absorption are secured by firm packing and selected material in the manufacturing process. Such material and packing seems to be prac-

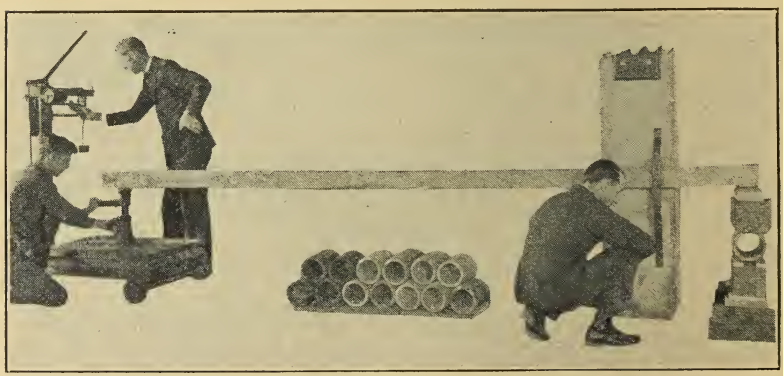


FIG. 26.—DEVICE FOR TESTING CLAY TILE

By this means the breaking point of tile can be determined.

ticable only in the thick walls of the 12-inch tile and the larger sizes. Where extra-quality methods and materials are used in the smaller sizes, they are too expensive to compete with good shale or clay tile.

Ten drainage systems that have been in operation from three to nine years, each area containing some deep peat as well as some shallow peat with a clay subsoil, showed that the concrete tile four to eight inches in diameter laid in contact with peat had weakened until they were only 80.5 per cent as strong as similar concrete tile from the same lots that had lain the same length of time in a clay subsoil. Strength tests were made on 140 tile.

The 12-inch tile laid on the University Marsh in 1920 were so well made that they have but few signs of unfavorable action by the peat, and none that appeared the past year. On the contrary, they are about two and one-half times stronger than shale tile laid the same

time. This allows a reasonable factor of safety for any weakening effect of the peat in the years to come, and for other peats more acid in character than the University Marsh. The engineer, however, must be alert in detecting the occasional weak concrete tile that may find its way into a lot of good ones, due possibly to the use of partly set sweepings from the floor of the factory.

Engineers accepting concrete tile in peat are advised to insist on (1) steam curing; (2) absorption less than 7 per cent of the dry weight of the tile; and (3) a breaking strength of 1,600 pounds per linear foot for all 30-day-old tile up to 16 inches in diameter, with an increase of 100 pounds for each inch in diameter thereafter. A strength two-thirds as great as this is permissible for concrete tile laid in a clay subsoil and for shale tile in any soil for all depths up to six feet. At greater depths, the greater strength is required for both shale and concrete tile. In deep cuts a curved trench bottom exactly fitting the tile is essential. Another safety device is to fill the trench on the installment plan after the tile are laid to allow time for part of the filling to settle and become firm before the rest is put back.

Some of the clay tile used in Wisconsin are too soft, porous and weak to be recommended at any depth. Such weaknesses are usually manifest by high breakage in shipment.

The testing device shown in Figure 26 has proven its worth. One arm of this lever is eight times as long as the other. If the dead weight of the level on the scale is 90 pounds before the lift is applied, and the tile breaks at 230 pounds, the actual lift is 140 pounds. This multiplied by eight gives 1,120 pounds of pressure applied upon the tile. To compensate for the wooden bearings instead of soil 50 per cent must be added, which would make 1,780 pounds the breaking point of the tile if laid in soil.

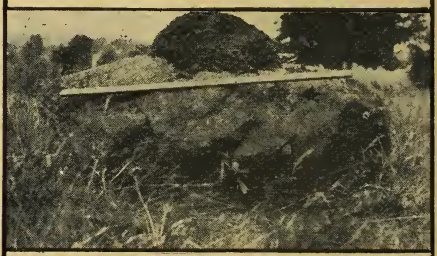
Sodatol, a New Explosive Mixture

AT THE close of the late war there remained in the various government arsenals large quantities of war explosives, such as picric acid, TNT, and nitrate of soda. Large amounts of the picric acid have in recent years been used throughout the country for land clearing, road building, and other purposes at a great saving in cost over the more common forms of explosives previously used.

Investigations during the past year by John Swenehart (Agricultural Engineering), in cooperation with the Bureau of Public Roads of the United States Department of Agriculture, have evolved a new explosive mixture composed of 45 parts of TNT and 55 parts of sodium nitrate. This mixture, known as *Sodatol*, can be produced from the government supplies at a price which makes a saving of 12 to 25 cents per pound to the farmers of the state who took advantage of this opportunity by the purchase of 2,106,000 pounds in the fall of 1923.

To overcome shipping, handling, and storage problems, preparation of this material in cartridge form was necessary. After experiments

A.—Wisconsin used over 2,000,000 pounds of sodatol this last season.



B.—The mud cap replaces drilling for rock blasting. Cheap explosives cost less than extra labor.

C.—Sodatol has shattering power to crack the big ones. When breaking stones this way, workers should keep out of range of flying fragments.

FIG. 27.—SODATOL, THE NEW EXPLOSIVE, WORKS WELL ON STUMPS

had determined the proper amounts of the ingredients to be used in a mixture for best results, arrangements were made to have it packed in cartridges 1.25x8 inches weighing about seven ounces each and having a working strength approximately equal to the cartridge of the ordinary dynamite weighing about half a pound. This means that sodatol is about 15 to 20 per cent stronger than ordinary dynamite and has a shattering strength approximately equivalent to 40 per cent ammonia dynamite.

Nitrate of soda, one of the ingredients used in the making of sodatol, absorbs water readily, but in a mixture with TNT in properly paraffined cartridges the moisture encountered in agricultural work does not interfere with its use. Small quantities of water prevent explosion of the material and cannot be readily removed. It is essential that it be kept dry at all times, which is unlike the requirements for handling dynamite or picric acid.

Sodatol is not highly inflammable and burns slowly without explosion in small quantities. It is not sensitive to moderate shocks and hauling, which makes it safe to use for all ordinary purposes. Since the material is slower than picric acid and relatively more insensitive, it is less efficient for mud-capping of rocks or ditch blasting.

Results of various tests indicate that sodatol is a satisfactory explosive for all general work. It stands storage without deterioration and produces no disagreeable effects upon the health of the workers or headaches when used in open-air blasting. A large detonator such as the No. 6 blasting cap or an electric blasting cap should be used in detonating sodatol.

Farmers' Condition Improved in 1922

DURING 1922 the financial condition of farmers has shown an appreciable improvement over that of 1921. Surveys made under the direction of P. E. McNall (Agricultural Economics) in Walworth, Washington, and Fond du Lac counties indicate that this improved status is due to the efforts of the farmers in readjusting their operations rather than to any change in the prices of farm products. The study showed that the farmers in these counties reduced their cash farm expenses from an average of $1,743 in 1921 to $1,576 in 1922. The practice of greater diversification in 1922 over 1921 is another factor which helped to improve the net income of the farmer. While the sale of dairy products decreased from $2,479 per farm in 1921 to $1,926 in 1922, the returns from the sale of hogs and poultry amounted to $463 more per farm in the latter year. The fact that 1922 was a better crop year also made possible the carrying over of about $200 worth more of feed per farm than was carried over during 1921.

It was again shown that the production per cow is still the most important factor in increasing net returns on the dairy farm. The group of farmers in this survey whose herds sold less than 5,000 pounds of milk per cow during the year received no compensation for their time and only 3.3 per cent of interest on their total farm invest-

ment. On the other hand, farmers whose herds sold from 5,000 to 7,000 pounds of milk per cow, while receiving no compensation for their labor, received 4.7 per cent interest on their total farm investment, which is an increase of 1.4 per cent over the interest rate earned on farms where the cows produced less than 5,000 pounds of milk. Farmers from whose herds were sold more than 7,000 pounds of milk per cow during 1922 received on an average 5 per cent return on an investment averaging $22,000; over and above this, they averaged $244 each for their time as operators of these farms. All this goes to show that to make the dairy farm pay, high production per cow is essential. These figures verify the observation that the farmer's condition is improving, but obviously the income of the farms is still too low to yield a fair profit.

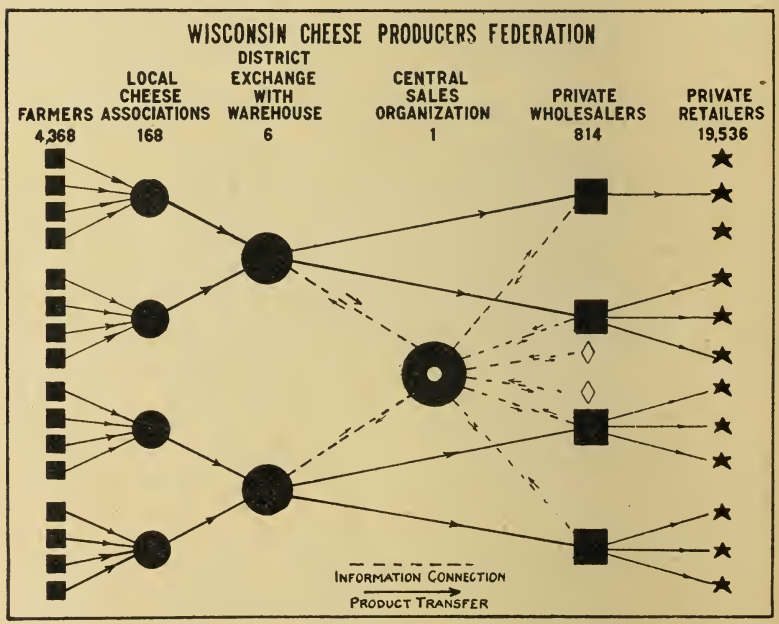


FIG. 28.—HOW THE WISCONSIN CHEESE PRODUCERS' FEDERATION MARKETS ITS PRODUCTS

In organizing commodity companies, there are two main forms, the federated type, illustrated above and the centralized type which omits only the local and district operating associations.

What Form of Cooperative Organization Is Best?

IN RECENT years there has been a great deal of misunderstanding over the use of various terms employed with cooperative and commodity marketing. Many forms of cooperative effort have been made known, and commonly they are not very well understood. In order to understand what form of cooperative organization is best, it is essential that there be a clearer understanding of the difference between the various forms prevailing.

In order to determine the best forms of cooperative organization in use, a survey of twenty cooperative companies in three Pacific Coast states and British Columbia was conducted by Theodore Macklin (Agricultural Economics) within the past year. This survey showed that two forms of organization are most frequently used: (1) systems of federated local associations, and (2) single central individual membership associations. Either of these forms of organization may develop so as to practice commodity marketing, and either may be organized on the basis of a non-stock-non-profit incorporation or on a regular stock and patronage dividends-profit incorporation. The nature of the commodity to be handled, the object to be attained, and local conditions must usually determine the form of organization selected by an enterprise.

There is no single satisfactory plan of cooperation for marketing. The cooperators who have been so successful on the Pacific Coast have selected the plan which seemed most likely to attain their objective. In organizing for cooperative marketing each group of actual or prospective cooperators must use judgment based on understanding as to how they shall organize and conduct their business operations.

Farm Ownership High in Wisconsin

FARM ownership is higher in Wisconsin than in any of the bordering states. In fact, the amount of tenancy in the state does not exceed 14 per cent. In view of the high percentage of farm ownership, a study was made under the direction of B. H. Hibbard (Agricultural Economics) of the various methods of acquisition by which the farmers of the state have acquired their farms.

These studies showed that a very considerable number of the farm owners of today have at one time or another been hired men and apparently the number of such farm owners is increasing. In 1882 exactly 54 per cent of the farmers had been hired men; in 1922 this number had increased to 62 per cent. It is also found that the number of farm owners who at some time had been farm tenants is increasing. In 1872 only about 11 per cent of the farmers had worked as tenants, while in 1922 this percentage was 53. It is interesting to note that the period of tenancy which precedes ownership is becoming somewhat longer, especially in the older portions of the state. The average age at which men now acquire farms also shows a tendency to advance. Thirty years ago the average age of the men buying farms was slightly over 27 years, while in 1922 it exceeded 32 years.

It was found that 66 per cent of the farms were purchased outright on a business basis; that 11 per cent were acquired mainly by purchase, but with some other form of assistance; 5 per cent were inherited; nearly 3 per cent homesteaded; and 2 per cent received as gifts. It is further noted that boys coming from small farms become tenants a little later in life than those from the large farms, and that the length of time for which they remain as tenants is gradually increasing.

The number of persons on farms who were not born upon farms seems to be increasing. According to this survey, the actual number of these was 20 per cent of the total, but other studies seem to indicate that this figure should probably be slightly lower for the state as a whole. When it comes to boys leaving the land, the study seems to indicate that the large farms lose fewer young people than the small farms. Nearly all of the farmers have worked away from the farm for some time. Relatively more men from large farms have gone back to farming than of those that came from the small farms. Moreover, men who were boys on small farms still own smaller farms than do those who came from farms of larger size, which seems to show that the size of farms perpetuates itself at least for a time.

Rural Life Studied

THE RESEARCH in rural life was concerned with rural religious organizations and town and country relationships during the past year. Both of these were conducted by J. H. Kolb (Agricultural Economics).*

The first project, "Rural Religious Organization," is a study of present-day organization of religious groupings in one county. No purely religious question, as such, is considered at all, but the problem was to map the various rural church groups, enumerate their constituency and then study into the factors and conditions lying back of this present-day organization. This plan involved tracing these groups back to their European or early American sources, analyzing their developments in the changed situation and of showing the interrelation of the various national and local constituent bodies. In the county studied, 117 such bodies were found distributed according to three major groupings as follows: Lutheran bodies, 47, including five synods and having a combined constituency of slightly over 11,000 communicant members; Roman Catholic bodies, 22, with a membership of 6,590; and "Reformed" bodies representing all non-Lutheran protestant groups, 48, including 11 different divisions with a total of 3,693 members.

Town and Country Relationships. The second project was completed after two years of field and laboratory work. Six small towns were selected in three counties and all of their service institutions in any way in contact with the farming population were minutely studied. These institutions, of course, included retail stores, marketing agencies, schools, and churches, or social, fraternal and recreational organizations. Then in the outlying trade areas of these six towns 787 farm families were personally visited and questioned in detail about their relationship to these near-by towns. This service relation of town and country is sixfold.

* Cooperatively with the Bureau of Agricultural Economics, United States Department of Agriculture.

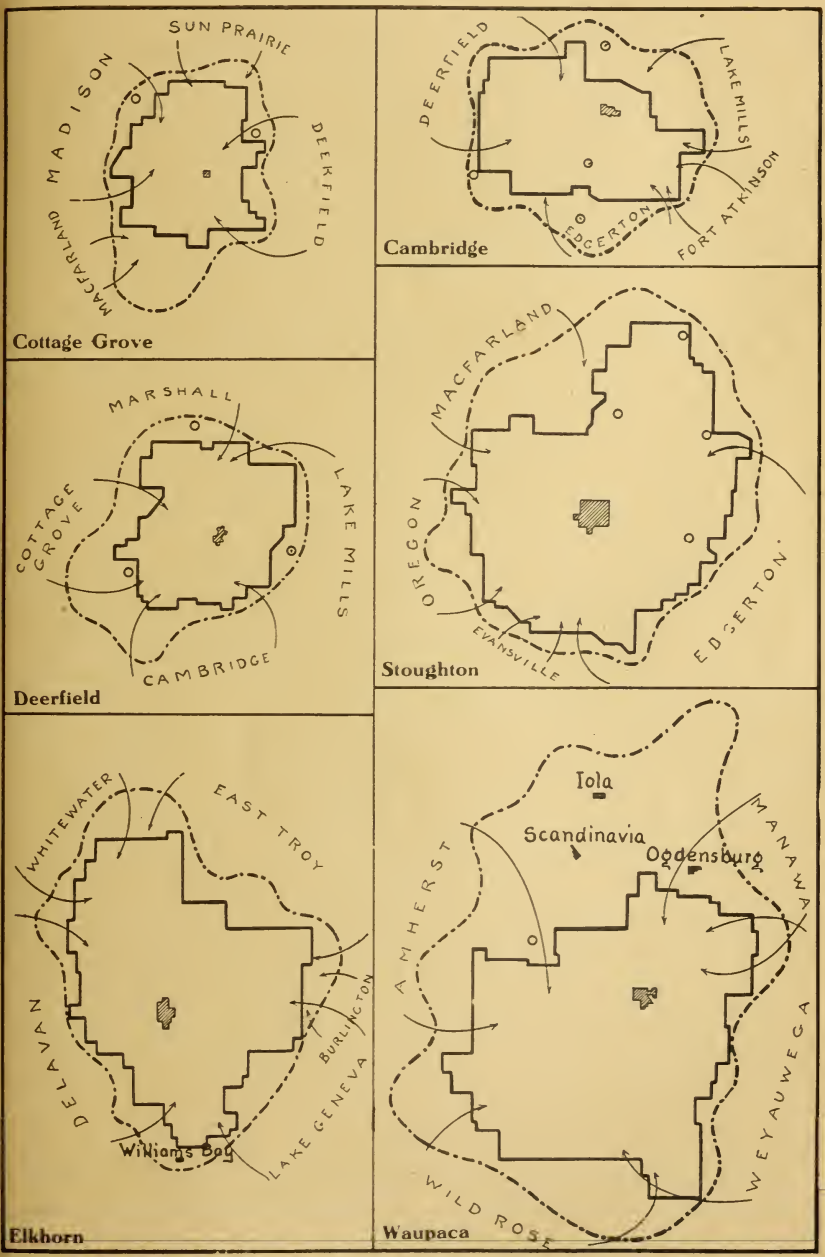


FIG. 29.—TRADE ZONES ARE AN INDEX OF TOWN AND COUNTRY RELATIONS

The solid black lines indicate the general trade zones while the broken swinging curves represent the maximum area to which any service from the town extends. The arrows show encroachments from nearby towns.

The economic service includes merchandising, marketing, and financing. The merchant by selling his wares to the farmer contributes directly to the later's standard of living. Marketing is the reverse side of the relationship; it is the local assembling of the farmers' product for the world consumption. Financing works both ways, the farmer buying and selling in town and the merchant buying and selling with the farmer. Both processes require financing.

The educational service holds the key to the future with reference to social attitudes affecting town and country relations. This service is presented locally by schools, libraries and lyceums of various sorts for lectures, music, drama, and art.

The religious service has to do with those idealizing and motivating forces in rural life. Its local representative is the church and its various organizations of benevolence and religious education. It has at its command music, drama, beautiful imagery, commanding architecture, reverent rituals, and inspiring personalities.

The social service is concerned with those functions which make for sociability, contentment, and happiness, and quite as much with those of social welfare represented by programs of health, charity or corrective work.

The communication service has within its grasp powerful means for unifying or dividing community life. The channels for understanding and communication are here. They are such as the telephone, telegraph, and the radio; the mail service; the newspaper and magazines; and transportation in all its forms, for the roads themselves become important means of communication.

The organization service. No service relations can be effective or permanent until they are appropriated, incorporated and incarnated within the life of local groups of people. This organization service, whether of cooperative endeavor, of community organization (which is nothing more than the local harmonizing and harnessing of all interests), or that of leadership from within, become matters of prime importance demanding more than a haphazard or casual attention on the part of the larger town and country community.

In summary the implications from the study may be expressed from the viewpoint of the townsman and second from that of the farmer. For the townsman it means that his town must become the specialized service station for the larger community. Each town may well specialize to those services it can render most effectively. This means, of course, that no one town and its community can live unto itself, but must work out interrelations with other towns and their communities.

The implication for the farmer is the assumption of a keener responsibility for the larger community life rather than attempting to hold to a family or a neighborhood economy. The farmer is in real need of this larger organization relationship where his own interests may be safeguarded, but at the same time united with those of his town or city in order to effect an efficiency commensurate with the greatly expanded needs of his day.

It Pays to Inoculate Canning Peas

FOR A NUMBER of years canners have thought it advisable to inoculate peas grown on light soils where the inoculation often exerts a marked influence on the yield. On the more fertile soils inoculation has not generally been considered worth while because there seemed to be no material difference in the resultant crops. Recently, however, some of the canning companies have made comparative trials of cultures prepared in the Agricultural Bacteriology department by using inoculated and uninoculated seed in the same field. While they were often unable to see any difference in the crop as it stood in the field and did not consider it worth while to continue the inoculating process from outward appearances, a careful determination of the crop after harvesting has shown that the inoculation has a very good effect upon the yield of shelled peas and is profitable even on the more fertile soils as well as on the lighter ones.

The Garden Canning Company, of Evansville, after making comparative trials on fertile land reports a yield of 2,165 pounds per acre for the uninoculated land and 2,894 pounds for the inoculated fields. When calculated at 3 cents per pound for the shelled peas, these figures show an increase of $21.87 per acre which was brought about by inoculation material costing $1.00 per acre and leaving therefore a net return of $20.87 due to this extra work.

The William Larsen Canning Company, of Green Bay, reports an increase of 267.2 pounds per acre of green shelled peas, making a net monetary increase of $7.01 per acre. The report of this firm states that there was no noticeable difference in the appearance of the fields. On trials of this sort run in Walworth county, County Agent Merriam reports an increase of 254 pounds of green shelled peas per acre due to the inoculation, making a net monetary increase of $6.62 per acre. Again in this case there was no apparent difference in the growth of the plant though the color of the inoculated peas was somewhat darker.

The pea canners of the state, through their state organization, are bringing these results to the attention of the different people interested in this industry. The introduction of such practices is the surest way to reduce the cost of production without much additional expense. The effect will be to add materially to the fertility of our soils by keeping up the nitrogen content.

Experiments With Silage

WISCONSIN now has over 100,000 silos, and silage plays an exceedingly important part in feeding the 2,200,000 dairy cows of the state.

From year to year the number of inquiries about silos and troubles experienced in making good silage has constantly increased. The departments of Agricultural Chemistry and Agricultural Bacteriology have continued their experiments from both the chemical and biological points of view.

Moldy Silage. Moldy areas in silage have given dairymen in certain sections of the state unusual concern within the past two years. So far, the only explanation is that the corn was usually ensiled when too dry and that, in certain areas, the oxygen in the contained air was used up so slowly by the live plant tissues of the corn that mold growth was made possible for a short time. It seems that the diffusion of oxygen is slow in the tightly packed silage; if this gas is not taken up by the respiration of the plant tissues in a given area, it does not pass into the surrounding material rapidly enough to avoid the growth of mold. It is possible that the growth of mold in these spots occurs the first day or so after the material is placed in the silo. Thorough compacting will help to some extent in overcoming this, but more particularly corn should not be allowed to get too ripe.

Silage Fermentation Trials. In the fall of 1922 a stave silo was filled with corn in excellent condition, with which to make a complete chemical and bacteriological study of the silage at various periods of fermentation. The work was carried out under E. G. Hastings and E. B. Fred (Agricultural Bacteriology) and W. H. Peterson (Agricultural Chemistry). The most striking result was the rapidity with which the oxygen disappeared from the silage after ensiling. It was practically all consumed within two or three hours, and a corresponding increase in the carbon dioxide content of the silage air was noted. Gradually the carbon dioxide content decreased and its place was taken by nitrogen. It appears that the carbon dioxide gradually diffuses out and is replaced by nitrogen instead of normal air because the oxygen in the air is removed by mold growing on the surface layers of the silage.

Ensiling Partially Dried Alfalfa. In the summer of 1922 Messrs. Fred and Peterson ensiled some alfalfa in the manner advocated by Mr. Samarini, of Italy. This material was partially dried by exposure after cutting to 30 or 40 per cent moisture, then tightly packed and heavily weighted; and it was found that the silage produced was brownish green in color, had a pleasant odor, and was readily eaten by cattle. There was little loss of dry matter during the process (about 5 per cent).

The success of this method seems to depend upon the proper reduction of the water content in the material ensiled to a point which will not permit bacterial growth and which will, at the same time, retain enough living plant tissue to remove the oxygen from the silage air by respiration, thus providing suitable conditions under which the silage will be protected from mold and ordinary bacterial growth. On the whole, it seems that in practical use a farmer would have difficulty in getting material such as alfalfa dried to the proper degree for silage, and it is doubtful whether such a practice can ever be recommended under conditions where alfalfa can be satisfactorily converted to hay.

New Test to Separate Strains of Legume Bacteria

THE LEGUME bacteria are divided into natural groups depending upon the kind of plants they are able to invade and produce root nodules. The agglutination reaction which has been used by J. W. Stevens (Agricultural Bacteriology) divides the natural groups into a number of subgroups. These subgroups differ in that the members of one subgroup may be more effective in promoting the growth of a higher plant than those of another subgroup. The variation in the effectiveness of the cultures belonging to different subgroups is shown in Fig. 30.

The variations seem to be more in the ability of the bacteria to assist the green plant than in the actual nodule-forming power. In the experiments the nodules were sometimes more abundant on the roots of the plant inoculated with strains that produced the smallest growth than on those inoculated with strains that produced the largest growth. The plants making the largest amount of growth contained the higher percentage of nitrogen.

FIG. 30.—LEGUME BACTERIA CAN BE PEDIGREED ON BASIS OF NITROGEN-FIXING POWER

By applying the blood test used in detecting typhoid fever, the bacteriologist is able to separate alfalfa bacteria into high or low nitrogen-fixing groups. This new discovery opens up new fields in producing commercial cultures.

Soybean Inoculation

WITH THE increasing acreage of soybeans now grown in the state, there is much interest in successful cultural practices. While the importance of soybean inoculation has to some extent been recognized, there is yet much to learn.

Because such varied results were obtained in field trials with inoculated soybeans a carefully planned series of trials has been conducted over a period of four years by W. H. Wright (Agricultural Bacteriology). From a great mass of data collected the following findings stand out:

1. Different strains of bacteria used in inoculating soybeans differ in their nitrogen-fixing efficiency.
2. Different strains of bacteria used for soybean inoculation differ in their power of producing nodules on the roots of the plants as shown by actual count both as to number and size of nodules.

3. Different varieties of beans differ in their relative "susceptibility" of inoculation.

4. The efficiency of nitrogen fixed varies with the soil composition and reaction.

The results in the following table were obtained by inoculating soybeans with standard cultures that are ordinarily sold. These cultures contain a mixture of several strains of bacteria, and the variation in results under different soil conditions is interesting.

TABLE VIII—SUMMARY OF 1921–22. FIELD EXPERIMENTS WITH INOCULATED SOYBEANS

County	Year	Farm	Soil and reaction	Variety Soybeans	Gain in dry weight due to inoculation		Gain in nitrogen content due to inoculation
					Lbs. per acre	Per cent	Per cent
Adams	1921	1	Medium acid sand	Ito San	270	7.9	4.1
Adams	1921	2	Medium acid sand	Ito San	105	3.8	21.6
Adams	1921	3	Medium acid sand	Manchu	324	8.0	5.2
Adams	1921	4	Medium acid sand	Ito San	85	2.5	3.8
Green Lake	1921	1	Slightly acid sand	Manchu	30	1.0	6.6
Green Lake	1921	2	Slightly acid sand	Wis. Black	669	26.0	15.0
Columbia	1922	1	Medium acid, sandy loam	Machnu	1,581	73.6	28.4
Columbia	1922	1	Medium acid, sandy loam	Wis. Black	1,943	48.8	4.8
Columbia	1922	1	Medium acid, sandy loam	Hollybrook	2,446	74.3	27.1
Columbia	1922	1	Medium acid, sandy loam	Black Eyebrow	259	4.0	18.4
Columbia	1922	1	Medium acid, sandy loam	Chestnut	35	0.9	17.9
Columbia	1922	2	Medium acid sand	Hollybrook	1.504	38.3	12.0
Columbia	1922	2	Medium acid sand	Manchu	3,557	60.8	8.6
Columbia	1922	2	Medium acid sand	Wis. Black	1,795	50.6	16.3

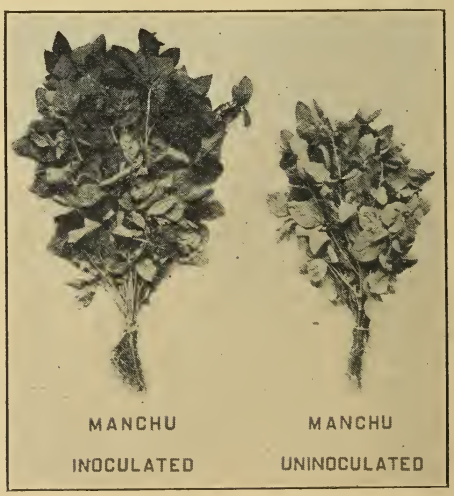


FIG. 31.—INOCULATION PAYS

Ten plants from an inoculated plot (left) and ten from an uninoculated plot (right). Inoculation increases yield per acre, also nitrogen content (as shown by color), and feeding value of crop.

Stinker Swiss Cheese

In view of the fact that Wisconsin produces over three-fourths of the Swiss cheese made in the United States, anything affecting this industry is of considerable importance. In the past year the amount of "stinker" cheese continued to increase; and because this putrefactive trouble often makes the cheese unsalable, investigational work is of interest.

It was found previously that butyric acid-forming bacteria were always present in the rotten spots, while few organisms of this type were also present in the good part of the cheese. Pure cultures of the butyric acid organism, however, do not produce any odor resembling the "stinker" odor. Continued work this year by E. G. Hastings and W. C. Frazier (Agricultural Bacteriology) has, however, resulted in isolating another organism from "stinker" cheese which gives a bad odor when grown by itself in sterile milk.

It was found that the only way in which this organism would produce stinker spots in cheese was its introduction into the cheese or into the milk from which the cheese was made either in combination with the butyric organism or with the gas-forming bacteria from Nissler cheese. Neither organism alone would produce the stinker spots. The tentative conclusion reached is that this trouble is caused by a combination of organisms, which may readily occur in milk, rather than by any single type of germ.

Role of Bacteria in Curdling Evaporated Milk

The curdling of milk by heat has been a subject for considerable study because of its importance in the evaporated milk industry. Previous work has shown that the balance of salts in milk may determine whether or not a given sample will coagulate upon heating and that bacterial action on the milk may influence its heat coagulation.

Experiments have shown that acid formation by bacteria in general, assists coagulation, but that acid in limited amounts inhibits it. It was thought that the type of organism which causes the "sweet curdling" of milk, i.e., curdling without the production of much acid, might have a considerable influence upon the heat coagulation of milk. W. C. Frazier has studied a number of these organisms. When portions of a milk culture of these organisms were added to milk in small amounts, they were found to inhibit heat coagulation, but larger amounts assisted it.

The coagulating ability of such organsms is due to an enzyme secreted by them. This rennin-like enzyme, which is similar to the coagulating enzyme found in the rennet extract from calves' stomachs, was isolated in a more or less pure state. Tests with the purified enzyme have shown that when acting alone it has comparatively little influence upon the heat coagulation of milk and that acidity is a more

dominant factor in the action of the bacteria. It was also found that the enzyme was sensitive to high temperatures. Heat at 140°F. (60°C.) for twenty minutes weakened it considerably while 150°F. (70°C.) destroyed it entirely, which shows that such enzyme must be destroyed during the preheating process and does not function during the evaporation or sterilization of milk.

Heat Coagulation of Milk

THAT THE salt composition of milk is of practical importance in a number of ways has been shown in previous work. Among these are the heat coagulation of evaporated milk, the rennet coagulation of milk in cheese making, and the coagulation of milk in the alcohol test.

There are indications that the feed consumed by the dairy cow has an effect on the salt composition of the milk. Feeding experiments were therefore conducted by H. H. Sommer and W. L. Lerch (Dairy Husbandry) to determine whether the mineral intake of the dairy cow influences the composition and properties of the milk.

The general plan of the experiments was (1) to feed cows on either a normal or a low calcium ration first and later to add inorganic calcium to this ration, and (2) to study the milk produced under these conditions for (a) Titratable acidity, (b) Hydrogen ion concentration, (c) Alcohol coagulation, (d) Heat coagulation, (e) Heat coagulation of the concentrated milk, and (f) Analysis for calcium, phosphorus, and citric acid content.

In the first experiment four cows were fed on a winter ration low in calcium in the preliminary period. Later 100 and finally 200 grams of precipitated calcium carbonate were added to this ration per day. There were slight fluctuations in the properties of the milk, but they were not abnormal and bore no consistent relation to the change in the ration, which indicated that in this experiment the feeding of the calcium carbonate did not produce any change in the properties of the milk. Since the results of this experiment were contrary to those of an earlier experiment in which the feeding of calcium carbonate affected the alcohol coagulation of the milk, it was thought that vitamine D, which governs the assimilation of calcium, may have been lacking. The experiment was therefore repeated and this factor was furnished by feeding 100 c. c. of cod-liver oil per day per cow, but without any effect on the properties studied.

Since the cod-liver oil was given only once a day, it undoubtedly did not come into contact with all portions of the feed and its effectiveness may for that reason have been reduced. A more satisfactory experiment was therefore conducted in which the vitamine D was furnished by green feed. Three cows were given green feed to which bone meal was later added. The addition of the bone meal caused the milk to coagulate more readily in the rennet and alcohol tests, and produced a slight change in the heat coagulation, although analyses

failed to show an increase in the calcium content and there was no change in the acidity of the milk.

When the changing of the cows from the winter ration to pasture feeding was studied, the analyses of the milk showed that there was an increase in the citric acid content, averaging 0.012 per cent on 14 samples. This increase in the citric acid content caused somewhat slower rennet and alcohol coagulation. There was no change in the acidity of the milk.

It appears, then, that changes in the mineral content of the ration failed to produce any change in the acidity of the milk, but that under certain conditions, especially in the presence of green feed, the mineral intake may affect the salt composition enough to cause a noticeable change in the rennet, alcohol, and heat coagulation of the milk. Further experimental work is necessary before final conclusions can be drawn.

It is known that in the manufacture of evaporated milk the temperature to which the milk is "preheated" before it is concentrated later affects the coagulation of the concentrated milk when it is sterilized. High preheating temperatures cause the milk to coagulate less readily. By comparing milk made with a preheating temperature of 180°F. with another portion of the same milk preheated to 210°F. Messrs. Sommer and Lerch found that the milk preheated to 180°F. coagulated much more readily in the sterilizing process. Analyses showed that the milk preheated to 180°F. contained 61.3 per cent of its original albumin content in a soluble form, while the milk preheated to 210°F. contained only 39.6 per cent. Further, the milk preheated to 180°F. contained 0.010 per cent more soluble calcium. The beneficial effect of high preheating temperatures in delaying coagulation of the evaporated milk is therefore attributed to the greater precipitation of calcium salts and coagulation of albumin at the higher temperatures.

New Butter Test Developed

MANY attempts have been made to devise a satisfactory method of testing butter for fat content at the creamery, but it has been difficult to find a test that could be used without special laboratory facilities. Recently, however, E. H. Farrington (Dairy Husbandry) has perfected a test which is thoroughly practical for general practice.

Among the problems in previous methods of testing the butter for fat content was the difficulty of getting a fair sample; slight errors produce considerable variation in results; and the reading of tests was often difficult because they are affected by changes in temperature and the fact that the fat content of the butter was improperly separated from the water, casein, and brine.

How the Test Is Made. The new method overcomes the old difficulty of obtaining a proper sample, because a number of small portions are removed from different parts of the package to be tested

and placed in a special cup where they are kept until the time for testing. When the testing is to be done, the cup is placed in water at a temperature of about 100°F. long enough to bring the butter to the consistency of heavy cream. Care must be taken not to heat the butter to so high a temperature as to separate the fat from the brine. When the entire sample has been brought into a creamy condition either by shaking or by beating with a case knife or spatula, it may be poured out into the testing bottle. The special bottles for testing of butter for fat content have a capacity of about 50 grams and a total length of not over seven inches with a diameter fitting into the pocket of the centrifuge of a Babcock milk tester. A cylinder or adapter is provided to hold each bottle in place while in the centrifuge because the pockets are too short to hold the bottle properly without support.

In the testing process the bottle is weighed accurately before and after filling so that exact weight of the sample may be known. Ordinarily about 47 grams are used.

The test bottles containing the weighed portion of butter are then placed in a water bath having a temperature of about 160°F. This melts the butter sample and the fat rises to the surface while the brine settles to the bottom. The casein or curd is more or less mixed through the fat or forms in a layer between the fat and brine. The preliminary heating helps to contract the curd and to give a clearer reading at the lower line of the fat column.

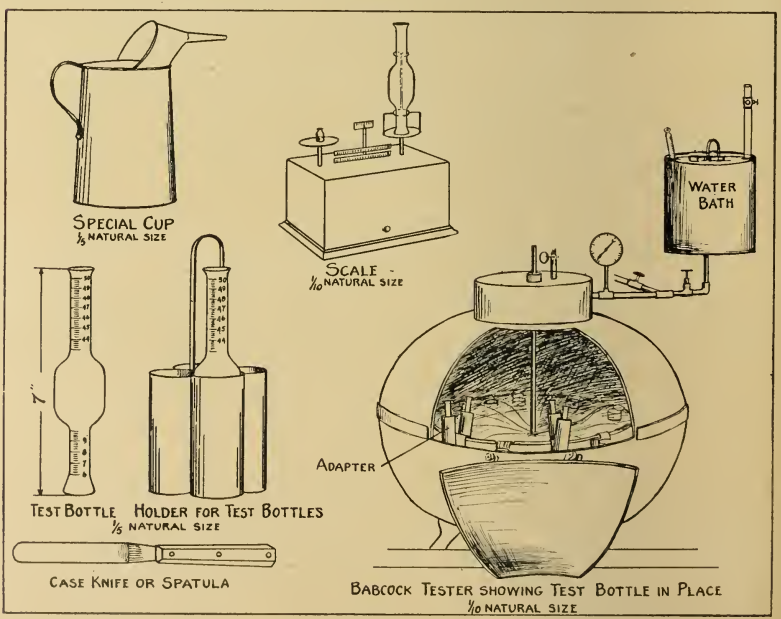


FIG. 32.—FARRINGTON BUTTER TEST FILLS A LONG-VOICED NEED

This device greatly simplifies the process of determining accurately the amount of fat in butter.

After warming the bottles for a few minutes, they are placed in the pockets of the Babcock centrifuge with an adapter to hold the bottles securely in place. The centrifuge should be hot, but no additional heat is needed in steam turbine tester.

After whirling these butter test bottles for 15 minutes, at full speed, they are taken out and placed in a water bath having a temperature of 140°F. where they remain for 10 minutes in order that the fat in the bottle may all reach the temperature of 140°F.

If the line between the brine, or water, and the fat is not clear, a few drops of hot water may be added and it will be noticed that this water will drop through the fat and form a clear layer between the fat and the casein at the bottom of the fat column. It is sometimes advisable to whirl the test bottle in the centrifuge a second time until a clear line is obtained between the lower portion of the fat column and the liquid below it. The test bottle should take a nearly horizontal position in the centrifuge during the whirling, otherwise the lower end of the fat column is not straight and it may be difficult to read.

Measuring the Fat. As soon as the butter test bottles have reached a temperature of 140°F. in the bath where they are placed after whirling, they are carefully raised out of the hot water, but not entirely removed from it. For each bottle a reading is made of the graduated tube at the top and also at the bottom of the fat column. The difference between these two readings gives the grams of butter fat, and if this reading is made quickly with the bottle partially dipping in the warm water, it can be made before there is much change in the temperature of the fat in the test bottle. Reading the fat column at a temperature of 140°F. is a very important point in getting an accurate test. Glymol may be used for reading the top of the fat column if desired, but it is not necessary.

Calculating the Percentage of Fat. The number of grams of fat shown by the reading is multiplied by 100 and divided by the grams of butter weighed into the test bottle; the figure obtained by this division is the percentage of fat in the butter.

The following figures will illustrate the weights and calculations made in testing butter by this method.

Weight of test bottle containing butter	106.9	grams
Weight of empty test bottle	58.7	"
Weight of butter taken	48.2	"

Reading of test bottle after whirling in centrifuge and holding 10 minutes at 140°F.

Upper reading of fat column	48.2	grams
Lower reading of fat column	8.5	"
Amount of fat in sample	39.7	"

This 39.7 grams fat multiplied by 100 and the product divided by grams of butter weighed into the test bottle, 48.2 grams, gives 82.3 as the percentage of fat in the butter tested.

Scoring May Raise Butter Quality

A STUDY conducted under the direction of Mr. Farrington has shown that, while Wisconsin is the second state in the Union in butter production, the 466 packages of butter from 207 creameries inspected during the year were not all of the highest quality. If the buyers of butter were governed strictly by the score of the butter and the published market prices of butter of a given score, then only 11.4 per cent of the output of our creameries graded up to the top price paid on the market during the fiscal year ending June 30, 1923. About one-fifth of the butter graded as the quality that is quoted at 1 cent under the top price and nearly one-third of it at 2 cents under top, while as much as 22 per cent graded as the quality quoted at 3 cents below top price, and about one-seventh of the total 4 cents under the average top.

Theoretically, butter scoring 93 is supposed to be entitled to the highest market price. In actual practice, however, it is found that there is so little butter on the market which scores 93 that butter scoring 92 usually sells at the highest market quotation. In general it may be said that butter scoring 91 or 92 may sell at 1 cent below the top of the market while butter scoring 90 sells for 2 cents below the market; so that for each point below 93 in the score a reduction of 1 cent per pound is made in the selling price.

Over a period of years the quality of butter in this state has been gradually improved, but more careful methods of manufacture can make for much further progress. With this in view, the Dairy Department has for some time been conducting butter scoring contests and encouraged Wisconsin creameries to send samples of their product for scoring and analysis. In each case, when a sample was sent for examination, complete record of the conditions under which it was produced accompanied it. In this way the judges, after scoring a sample, can make constructive suggestions for improvement. A report of the score, the analysis, and the comments of the judge, when sent to the buttermaker, are helpful to him in improving his product and also keep him informed about the newer methods.

For a time it was thought that an analysis of the butter samples might show a distinct relation of composition to quality. Some believed that low scoring butter contains too much moisture, and that a higher percentage of fat would probably often produce a higher scoring butter. A comparison of the analysis, however, shows no constant relation between the percentage of fat or moisture in butter and its quality or score; and that samples scoring 93 often contain as much or more moisture than samples rated lower. Very likely, quality is more the result of the conditions under which the product is produced, considering the entire process from the cow to the final package, than to the actual chemical nature of the ingredients. The study of this subject will be continued, and it is probable that the findings may have a considerable influence on Wisconsin butter.

Mineral Metabolism of Cows

A STUDY of the effect of supplementing summer pasture rations (green grass) with a calcium carrier was conducted because it was previously observed that green material contains more of the antirachitic vitamine than dried plant tissue, especially when plant tissues are dried under certain conditions. It has furthermore been shown that, during the winter feeding, the calcium equilibrium in a cow may be seriously impaired because of the absence of a generous supply of the antirachitic vitamine.

The present work was blocked out on the theory that a ration must contain, from the mineral standpoint, an ample supply of calcium and phosphorus, also an ample supply of an organic factor, the antirachitic vitamine, which controls the concentration of these elements in the blood stream and tissues. It was believed that the green material carries an abundance of the antirachitic vitamine and that supplementing summer pasture with a calcium carrier would lead to a generous storage of calcium during that period which would provide a reserve for the winter.

A trial was run with heavy milking cows receiving a ration of green grass, silage, and a grain mixture, supplemented with steam bone meal; and no attention was paid to the previous history of the animals. It was found that one animal which had been receiving alfalfa hay during the winter made no pronounced storage of calcium during the green grass period or on a ration of green grass and a bone meal supplement. Another animal that had been receiving poor roughage during the winter made a very pronounced storage of calcium in the body, but only when green grasses were supplemented with calcium. This leads to the belief that there are certain winter rations which will maintain the calcium balance of the animal and it is probable that animals receiving the best cured legume hay will not show lime depletion which results when poor hays, such as timothy (low in lime), or improperly cured hays are fed.

From the observations made it is apparent that a generous storage of calcium may ordinarily be expected by supplementing green grasses with a lime carrier. The data, however, show that grasses alone (lawn clippings used) would not accomplish this without the calcium supplement, especially with heavy milking cows.

Effect of Mineral Supplement to Good and Poor Roughages

IN ORDER to determine the effect of mineral supplements to good and poor roughages on milk production and reproduction in dairy cattle, a project has been under way with grade Holstein cattle since December, 1921. Four animals were fed timothy hay plus silage and a grain mixture; a second group of four received alfalfa hay plus corn silage and a grain mixture; and the third group of four also received alfalfa hay, corn silage, and a grain mixture. During the dry

period of 60 days Lot I received one-half pound of bone meal per animal per day; Lot II during the same time received one-half pound of bone meal; and Lot III received an equal amount of sodium acid phosphate (Na_2HPO_4).

The purpose was to determine the effect upon milk production and reproduction of the calcium and phosphorus in the ration, particularly the calcium in the roughage. The timothy hay used during the first year contained .73 per cent of calcium oxide, which is exceedingly low. The records for that year show that milk production in all three groups of animals was well sustained, the timothy hay group doing quite as well in this respect as the alfalfa group. There was, however, a considerable difference in the readiness with which the various groups bred, the timothy hay group being much slower in this respect than those receiving alfalfa hay. This group also showed a rapid decrease in the milk flow and dried off early after they were safely bred, which indicates that a depletion was probably taking place in this group as compared with the alfalfa group; and in attempt at self-preservation the milk production was lowered, which tends to show that maximum milk production is not obtained unless a properly balanced ration, considering the mineral requirements, as well as the nutrient protein and energy factors, is supplied.

Effect of Curing Methods on Availability of Calcium

THAT THE availability of calcium in legume hay may differ because of the destruction of the antirachitic vitamine in the curing process has been pointed out by previous experiments. This work, however, has been continued during the past year by C. A. Hoppert (Agricultural Chemistry). Clover and alfalfa hays were cured in different ways and tested out with dry, milking, and growing goats.

Alfalfa was cut in June and left out in sunshine and rain for ten days and therefore exposed to all the weathering (oxidative) processes of the atmosphere. In another case the alfalfa was dried in an attic under total darkness before an electric fan, where the process was completed in three days. Another supply was dried over heated coils, the temperature being kept at 140°F. to 158°F. (60°C. to 70°C.). Under this condition, 4.5 days were required to cure the hay. In another case the alfalfa was spread out on a large canvas, exposed to the sunlight for 17 days, but was brought indoors at night and exposed only on days when the sun was shining brightly. Another alfalfa hay studied was a commercial product made by a rapid drying process in which the green alfalfa is carried on a long moving platform while a current of heated air is continuously swept through it. In this drying process, a temperature of 200°F. is employed, and it is of 15 to 20 minutes duration. A series of clover hays were cured in ways similar to the methods employed with the alfalfa.

The earlier observations in this work tended to show that the antirachitic vitamine was destroyed by exposing hay to the sunlight and

weather, and that the assimilation of calcium by the body was thereby impeded was confirmed. The data acquired show that, though the alfalfa cured in the ordinary manner was quite as high in lime content as that cured in the dark, its lime content was completely unavailable even to a mature dry goat. Data are available which indicate that the hays dried in the sun, but not exposed to the influence of moisture such as rain and dew retained and antirachitic factor in greater abundance than those which were cured with exposure to all weather conditions such as dew, rain, light, etc.

Distribution of Anti-Rickets Vitamine. Efforts were also made to get some idea of the distribution of the antirachitic vitamine in nature. Yellow carrots in amount as high as 1,000 grams per day were fed without influencing the calcium assimilation in the least. The same was done with cabbage with similar results; and it is apparent that the distribution of the antirachitic factor is quite different from the distribution of other vitamines. Attempts to extract this vitamine from hays by alcohol (the solvent for vitamine A and B) have failed. It is known, however, that ordinary white light as well as the light of a mercury vapor lamp supplements a ration low in the antirachitic vitamine, producing an effect similar to that which is obtained when it is present. It is possible that animal life is dependent for its mineral regulation (calcium and phosphorus) more upon sunlight than upon the food material, although it is recognized that this organic factor does exist in such materials as fish liver oils, green plant tissues, and properly cured grasses. It may be that sunlight is needed quite as much to keep us in a healthy condition as it is to cure us from some diseases where its healing effects are now quite thoroughly recognized.

Effect of Roughages Grown on Acid Soils on Reproduction

NORMAL reproduction can be disturbed through improper nutrition. Observations over a number of years with dairy cattle have been steadily pointing to this fact. Especially is this disturbance brought about through low mineral intake accompanied by a correspondingly low intake of the antirachitic vitamine. It is believed that earlier results secured with wheat, wheat straw, and wheat gluten, whereby the offspring were dead or prematurely born, can be explained wholly upon the basis of deficiency, primarily of calcium and the antirachitic vitamine rather than upon the old theory of toxicity of the wheat grain.

Wisconsin has large areas of acid soils, and the roughage grown on such lands is inevitably low in lime. This fact has led to further trials in the feeding of roughages grown upon these soils, such as corn stover and timothy hay, to dairy cattle in order to determine their effect upon reproduction. Hay obtained from the Buena Vista marsh (a highly acid soil) in Portage county, containing less than 0.5 per cent of calcium oxide has given disastrous results in reproduction.

Rations containing plenty of protein, but low in lime, produced calves that were either dead at birth or so weak that they died shortly after. The feeding of timothy hay from Stevens Point which had a calcium oxide content of .7 to .8 per cent has given somewhat mixed results. In some cases the offspring have been miserably poor and died two or three days after birth; but in one case the offspring was better and lived.

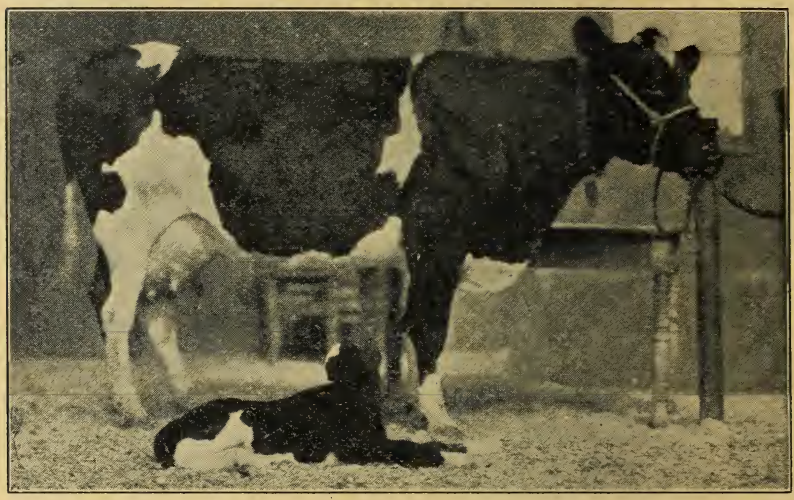


FIG. 33.—HAY FROM ACID MARSHES LACKS ELEMENTS NECESSARY FOR NORMAL REPRODUCTION

Timothy hay from Buena Vista (Portage Co.) marsh lacked lime and antirachitic vitamine so that calves were either weak or dead. Grain mixture used with hay supplied abundance of protein.

It is possible that the method of curing the roughage may be something of a factor in the results obtained. Further studies on the control of the processes used in the curing of the fodder may unravel this problem.

Prevention of Rickets in Swine

DURING THE past year an attempt has been made by E. B. Hart and H. Steenbock (Agricultural Chemistry) to measure the amount of cod-liver oil, which is an excellent antidote against rickets (antirachitic), that would be required to prevent the development of rickets in growing swine when fed a ration low in the antirachitic vitamine. In addition, various forms of calcium, such as limestone, bone meal, rock phosphate, and limestone plus sodium phosphate, were tried as supplements to a skimmilk-grain ration in order to determine if any difference resulted from the feeding of any of these forms of lime provided there was an abundance of the antirachitic factor present.

Observations so far indicate that there is no difference in the effect of the type of calcium carrier used for the prevention of rickets provided there is an ample supply of antirachitic vitamine. Floats, steamed bone meal, and calcium carbonate may be used without difference of result if the vitamine is present. It has been found that 20 c. c. of cod-liver oil per week, per animal, is sufficient to protect it against the development of rickets, though there is known to be some difference in the potency of the various cod-liver oils in this respect.

While the practice of feeding cod-liver oil to swine in England is being urged, workers at the Wisconsin Experiment Station do not feel that this practice is necessary except in an emergency. It is believed best to find common and natural sources of food as remedies whenever possible.

In this work it has been shown that the amount of inorganic phosphorus in the blood cannot be completely relied upon as an index to rickets. Individual animals have maintained the inorganic phosphorus in the blood while above 5 milligrams per 100 cubic centimeters of serum and yet been in a state of total collapse. In fact, the inorganic phosphorus of the blood may not be lowered in these cases until late in the history of the disease.

Do Cooking Methods Affect Vitamine Content of Peas?

BECAUSE of the prominent place which vegetables, especially those in canned form, are assuming in our diet, a study of the vitamine B content in early June peas prepared under different conditions was made during the past year by Miss Helen T. Parsons (Home Economics). In this work peas canned by the regular canning process and peas first cooked, then dried and powdered were used. Rats were employed as experimental animals throughout the trial.

It was the particular purpose of this experiment to ascertain the difference in vitamine B content between peas prepared by the regular canning process and those prepared by household methods and also to determine what proportion of the vitamine B content in canned peas is present in the peas themselves as contrasted with the amount contained in the juice. From the results obtained in these trials it appears that canned peas are inferior in vitamine content to fresh peas which are cooked by steaming and subsequently dried, but it does not appear that the vitamine B content of the pea juice is large enough to account for the difference noted. In fact, in this experiment the juice from the canned peas appeared to be relatively poor in vitamine B. This suggests the possibility that vitamine B is more unstable over a long period of time when in contact with water than in a dry condition or that some factor other than the canning process itself is responsible for loss in vitamine content.

While the trial showed that canned peas seemingly contain a smaller amount of vitamine B than peas cooked and dried, it also indicates that canned peas are not valueless as a source of vitamine B as has

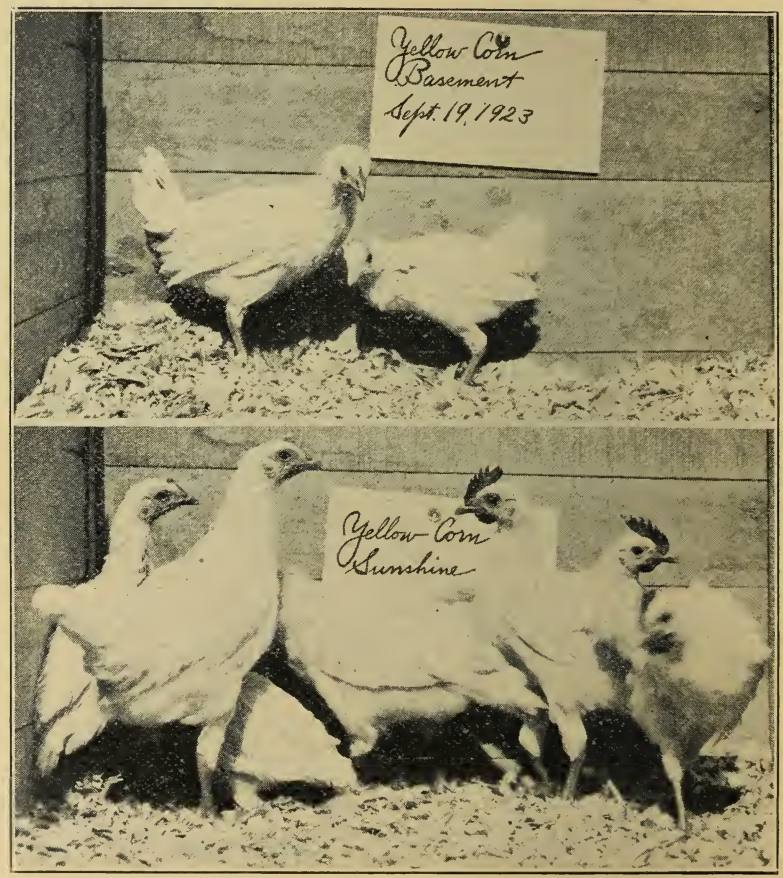


FIG. 34.—CHICKS ON A GOOD RATION WILL DIE WITHOUT LIGHT

The upper two birds are 60 days old and the only survivors of a group of 10 chicks fed on a ration of 97 parts yellow corn, 2 parts ground lime stone, 1 part of salt, and all the skimmed milk they would consume. They were confined in a clean, dry basement with the windows closed. Lack of sunlight killed them.

The lower group of birds received exactly the same ration as those above. Sunlight made the difference.

sometimes been supposed. Further investigation on this subject and kindred ones is necessary; and with the increasing importance of canned peas and other processed vegetables in our diet, a growing interest in work of this sort is likely to develop.

Direct Sunlight Is Factor in Animal Growth

WHILE it has long been known that sunlight plays an important part in the development of all of our green plants, the direct relation of this form of energy to animal life has but recently attracted the attention of men of science. Developments in nutritional studies of the past few years, however, indicate that in some cases at least light may be almost as important a factor in the normal

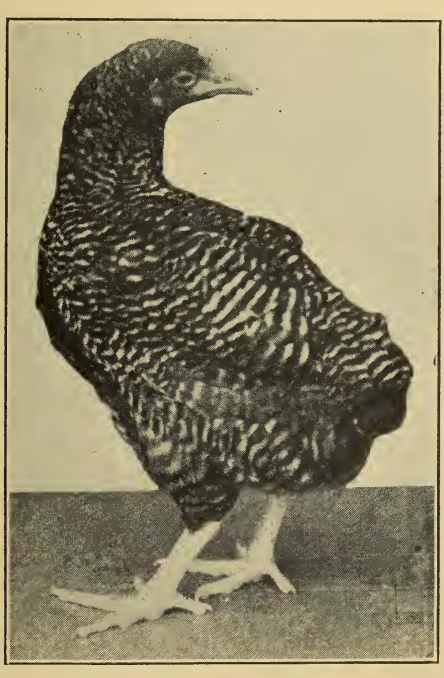


FIG. 35.—CHICKENS CAN BE RAISED ON A "TEST TUBE" DIET

The secrets of nutrition can best be discovered by growing birds on a compound ration made of chemically definite elements. These "synthetic" rations when used with cod liver oil to add vitamines permits successful rearing of birds. Weight here was 825 grams in 13 weeks.

development of certain animals as it is in the growth of our green plants. Furthermore, the effect of common window glass in filtering certain rays from the light of the sun as well as the different powers exhibited by sunlight at different seasons of the year are coming to receive careful attention.

That certain diseases, such as rickets, are the result of a deficiency of certain factors in the diet of animals has been conclusively proven. It has been shown that the substitution of yellow corn for white may overcome difficulties which have been encountered because of the lack of the fat-soluble vitamine in that grain; and that the use of green feeds or cod-liver oil has had a pronounced influence upon the health and the growth of various animals when fed on ricket-producing rations. Work of the last two years at this station has shown that the production of hens as well as the hatchability of their eggs may, to a very large extent, be dependent upon the supply of vitamines in their food and the same factors have been found to be of particular importance in the normal rearing of young chicks which, because of their early maturity and relative sensitiveness, make splendid experimental animals for studies of this sort. That the practical application of these findings may have an important bearing in the industry is no longer in doubt.

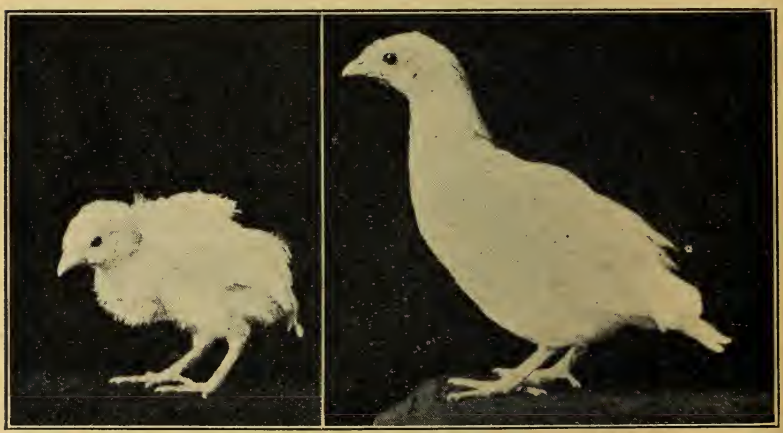


FIG. 36.—LACK OF SUNLIGHT AND ANTIRACHITIC VITAMINE STUNTS GROWING CHICKS

Chicks fed white corn 97 parts, powdered limestone 2 parts, common salt 1 part, and free use of skimmed milk were given sunlight but 10 minutes daily. Compare the bird on the left weighing 140 grams at six weeks of age with the bird at the right fed in the same way but exposed all day to sunlight. It weighed 210 grams at six weeks.

Continued work during the past year by H. Steenbock, E. B. Hart, and S. Lepkovsky (Agricultural Chemistry) and J. G. Halpin (Poultry Husbandry) has further demonstrated that sunlight or its equivalent has a very pronounced effect upon the growth and development of chickens. In this work, four experimental groups, each consisting of 10 White Leghorn baby chicks, were carefully studied in the Poultry Department. The first group received a ration consisting of 97 parts of white corn, 2 parts of ground limestone, and 1 part of common salt, together with free access to skimmed milk. The birds in this group were confined in a runway in the basement of the Poultry Building

with the windows closed. A second group received exactly the same ration as the first, but the birds were placed upon a board floor out of doors and exposed to sunlight during the day. A third group received yellow corn in place of the white corn in the above ration and, like the first group, were confined in the basement of the building. Group IV received the same ration as Group III, but was confined out of doors on board floors and in the sunlight in the same manner as Group II.

For the first two weeks growth in all four lots was apparently normal, due no doubt to the fact that the vitamine factors had been stored up in sufficient quantity in the egg yolks and the hatched chicks. After that time, however, the Group I birds practically ceased to grow, and all of the chicks in it soon died. The lot receiving yellow corn in place of white and confined to the basement in like manner as Group I made somewhat better growth and at the end of five weeks all but two of the chicks had died. The remaining two, however, continued to live for a long time and reached live weight of 340 grams, but from then on lost weight and died at the end of twelve weeks.

FIG. 37.—SUNLIGHT MAKES CHICKS GROW

Both these chicks started on the same plane as to weight and vigor. They were fed the ration (casein, dextrin, salts, agar and yeast) with some fresh green clover added. On this ration neither did well, but right hand chick was given a daily sun bath of 30 minutes.
Weight of right chick (7 weeks)—235 grams.
Weight of left chick (7 weeks)—95 grams.

On the other hand, both of the groups of chicks that were exposed to sunlight made a remarkable growth. Those on white corn did unusually well at first, but ceased to grow after reaching a weight of 600 grams. At this stage they also developed eye trouble and an unsteady gait accompanied by more or less dizziness. It became apparent that it would be impossible to raise chicks even in the sunlight with such a ration as white corn and skimmed milk, which is so obviously deficient in vitamine A. The birds produced in Lot IV on yellow corn, skimmed milk, and sunlight were in good condition through-

out the experiment and showed every prospect of continuing their growth to complete maturity. They produced eggs at the age of four months. In this lot all of the necessary factors were doubtless available—a good protein mixture, ample ash, and the necessary vitamines—and the deficiency in the antirachitic factor exhibited in the group receiving the same feed, but reared in the basement was doubtless made good by supplementing the ration with **sunlight.** Clearly, then, diseases in chickens, such as leg weakness, which is a form of rickets and caused by a lack of the antirachitic vitamine, may be overcome by supplementing with **sunlight** an otherwise satisfactory ration, because apparently this radiant energy goes a long ways toward overcoming any deficiency in the antirachitic factor that may exist. Its importance then in normal animal growth is in a measure at least kindred to the rôle it plays in the development of our green plants.

Leg Weakness in Chickens

THE NUMBER of reports received in regard to leg weakness in chickens this last spring was greater than in any previous year. This disease often makes it exceedingly difficult to raise chickens satisfactorily under confinement. Experimental studies by Messrs. Halpin and Hart have indicated that leg weakness as a disease is no different from rickets. Such factors as the low phosphorus content of the blood and low calcium content of the bones seem to show that leg weakness and rickets are kindred deficiency diseases.

Experiments conducted during the past year show that cod-liver oil, eggs, milk, and green feed are active agents in preventing this trouble in chickens when fed during the early growing period. A number of groups of chickens were fed separately with a ration consisting of 80 parts of yellow corn, 20 of middlings, 5 of lime rock, 5 of bone meal, and 1 of salt, together with skimmilk as a drink. It was found possible to make very satisfactory growth with chickens confined on a cement floor during the first six weeks of their lives.

Growth of Chicks Affected by Ration of Hens

EXPERIMENTS by Messrs. Halpin and Steenbock during the past year have shown that when chicks hatched from a ration of *white* corn plus pork liver were placed in the same brooder with chicks of the same age hatched from a ration of *yellow* corn plus pork liver and fed on a ration which was known to produce leg weakness, no difference occurred in the time in which this disease developed. It was found, however, that the chickens fed on yellow corn made better growth than did those from the white corn ration.

The number of chicks hatched from the white corn casein ration, however, was so small that comparative studies with them were not made. Most of these chicks from the white corn casein ration died within 48 hours after hatching. This indicates the necessity of vita-

FIG. 38.—RADIOGRAPH SHOWS EFFECT OF SUNLIGHT

An X-ray photograph of the birds shown in Fig. 37 shows poor skeleton formation in animal receiving the green plant tissues, but no sunlight. The bird exposed to sunlight had excellent bone formation.

mine-rich feed (as found in the yellow corn) in the poultry ration to maintain the hatchability of the eggs. Experiments have shown that a proper ration is important if eggs high in hatchability are to be produced.

Color of Egg Yolk Affected by Feed

THAT THE color of the yolk in eggs varies considerably with the quality of the ration fed to the hen has been known for some time. Experiments conducted during the past year by Messrs. Hart and Halpin have demonstrated further that, while white corn and similar feeds produced white yolks, and yellow corn and green feed produced yellow yolks, a slight yellowness in the egg yolks can also be obtained by the feeding of yellow carrots.

Feeding Thyroid Affects Plumage of Fowls

THAT HENS would assume cock plumage when their ovaries became inactive or were removed has been shown by previous experiments. But until recently there has been no known method whereby male birds could be induced to assume female plumage, though this condition has been known to occur naturally in certain breeds.

In trials conducted during the past year by L. J. Cole (Genetics) and D. H. Reid (Poultry Husbandry), it was found that when dried thyroid powders in regular doses proportioned to their weight were given to roosters whose feathers have been in part pulled out, these birds developed new feathers in place of those which had been removed and the new growth was of the female type. With check lots to which thyroid was fed, the normal male plumage was developed under similar conditions.

Raising Dairy Calves Economically

PROGRESSIVE dairymen know that the surest way to build up a high-producing, profitable herd is to raise the heifer calves from the best cows in the herd, sired by a bred-for-production, purebred bull. It is relatively easy to raise thrifty calves cheaply when there is plenty of skimmilk available, but in condensary, market milk, or cheese factory districts, the matter is more difficult.

To gain information on economical methods of raising calves under various conditions, trials have been carried on during the past three seasons by Messrs. Morrison, Hulce, and Humphrey (Animal Husbandry). As a check lot each year one group of four calves (Lot I) has been fed the sort of a ration used by dairymen who have plenty if skimmilk. This was not over 14 pounds of skimmilk a head daily, clover hay, and a mixture of corn, oats, wheat bran, and linseed meal. The calves were watered twice daily and had plenty of salt. In each

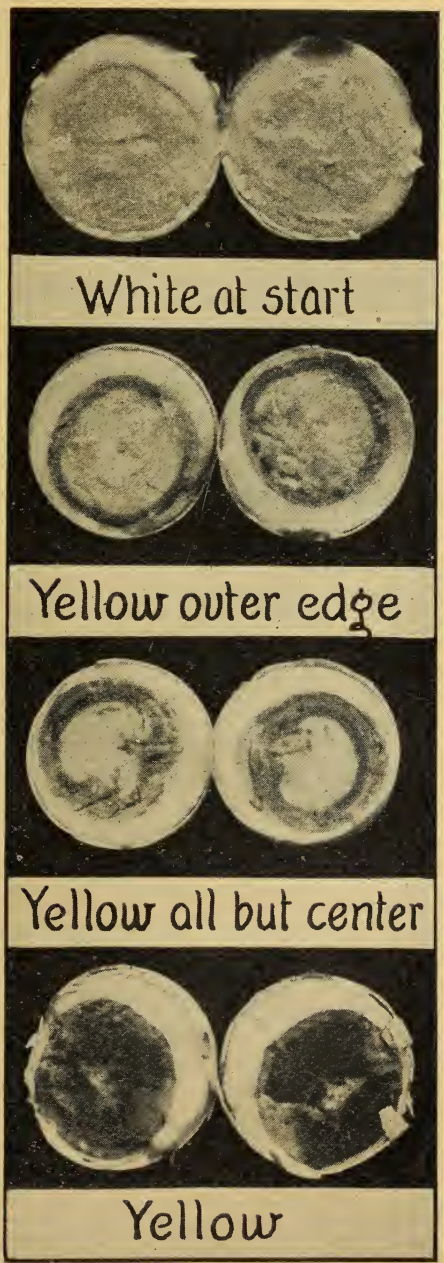


FIG. 39.—EGG YOLK COLOR DEPENDS ON RATION

Hens fed "white" ration (white corn, casein, etc.) produced pale egg yolks; when yellow carrots were added, "yellow" yolks resulted in 10 days.

trial they made excellent gains, averaging 1.76 pounds a head daily for the three trials.

Limiting the Skimmilk Allowance. In two of the trials other groups were fed similarly except that the amount of skimmilk was limited to 10 pounds a head daily, to represent conditions on farms where the supply of skimmilk for calf feeding is limited. These calves made very good gains, though somewhat less than Lot I, which was fed 14 pounds of skimmilk a head daily. They gained 1.52 pounds a head daily in comparison with 1.72 pounds for Lot I in corresponding trials. Owing to the lesser amount of skimmilk fed, the feed cost up to six months of age was $21.32, compared with $23.80 for Lot I. The calves receiving 14 pounds of skimmilk daily were slightly more growthy, although there was no apparent difference in the vigor of the two lots, and the gains of the calves limited to 10 pounds of skimmilk a day were actually a trifle larger than is considered normal.

These results show that good thrifty calves can be raised on an allowance of skimmilk limited to 10 pounds daily, if a good concentrate mixture and good hay are fed in addition. When an abundance of skimmilk is at hand, it is best to feed the larger allowance given to Lot I. However, sometimes it may be advisable to limit the allowance of skimmilk fed the calves in order to have more skimmilk for young pigs or poultry.

A Ration for Market Milk and Condensary Districts. Each year a third lot has been fed no skimmilk, but has been raised on a minimum amount of whole milk, which did not exceed 400 pounds for each calf from birth, or about 375 pounds from the fourth day after birth, when the dam's milk was salable. This was supplemented by a simple concentrate mixture rich in protein consisting of equal parts ground oats, ground corn, linseed meal, and wheat bran. After the calves were seven to nine weeks old, they were fed only this mixture with hay, water, and salt, no expensive calf meal whatsoever being fed at any time. In two trials these calves have made an average daily gain of 1.43 pounds at a feed cost of $22.64 per head to six months of age. This lot gained slightly less than Lot II, fed 10 pounds of skimmilk a head daily, but did remarkably well considering the small amount of milk fed. In fact, the gains would be considered normal for well-reared dairy calves.

These results show plainly that good thrifty calves can be raised on market milk in condensary districts at a reasonable cost by following this simple method, and without the use of any expensive commercial mixtures. In raising calves by this method, if a calf is delicate and not making good gains, it will be necessary to continue the feeding of whole milk longer than otherwise. In these experiments, however, little difficulty has been experienced in getting the calves entirely off milk at seven weeks of age in the case of Holsteins and eight to nine weeks in the case of Guernseys.

Good Calves Raised on Whey. In 1921 and 1922 two lots were fed whey supplemented by a concentrate mixture rich in protein, consist-

ing of three parts of ground corn, three of standard middlings, and four of linseed meal. The whey was pasteurized skimmed whey and no attention was paid to variations in sourness after the calves were used to this feed. In making the change from whole milk to whey somewhat more care was necessary than in changing from whole milk to skimmilk.

Lots thus fed whey gained on the average 1.49 pounds per head daily, or nearly as much as the calves fed 10 pounds of skimmed milk a day. This satisfactory gain was due in all probability to the fact that the whey was never allowed to stand in a filthy tank or can, but was fed with reasonable care and under sanitary conditions. Furthermore, a concentrate mixture rich in protein was used to make good the casein which had been removed from the milk in the cheese making process. The average feed cost of raising these whey-fed calves to six months of age was $21.58. These results show that thrifty calves can be raised on whey readily and cheaply when simple precautions are taken.

Do Not Neglect Watering Calves. The importance of supplying plenty of water to dairy calves even when fed a fairly liberal allowance of skimmilk is not appreciated by many dairymen. To gain definite information on this matter, in two of the trials a lot was fed the same ration as Lot I, except that no water was given these calves. Both lots received a liberal allowance of skimmilk, the good concentrate mixture mentioned previously, and common salt. Lot I received what water they would drink twice daily, while the other lot had no water except that occurring naturally in the skimmilk and the trifle in the "dry" concentrates and hay. The calves not given additional water gained only 1.32 pounds a head daily, while Lot I watered daily gained 1.86 pounds during corresponding trials. The lack of water, therefore, causes a surprising difference in the gains of calves. No farmer who wishes to grow his calves rapidly and well can afford to neglect supplying them with plenty of water—the cheapest item in the ration.

Soybean Hay for Milk Production

ESPECIALLY in the sandy sections of the state soybeans are of great and increasing importance as a source of legume hay for stock feeding. Even on heavier soils, soybeans are one of the best hay crops to grow when clover or alfalfa winterkills. As there is yet but little experimental data concerning the relative value of soybean hay and alfalfa hay for dairy cows, a series of trials was begun the past year by Messrs. Morrison, Savage, and Hulce.

This past winter Wisconsin-grown hay was compared with soybean hay raised on the University Farm. Manchu soybeans were cut when the pods had formed, and cured in windrow and cock so that a good grade of hay was secured. Two lots of six cows each were fed by the double reversal method on either alfalfa or soybean hay with corn

silage and a concentrate mixture of ground corn, ground oats, and wheat bran. Equal amounts of hay, silage, and concentrates were fed in the soybean hay and the alfalfa hay ration. However, 17.8 per cent of the soybean hay fed was not consumed, this part consisting of the coarse stems. On the other hand, there was practically no wastage of alfalfa hay.

Good production was secured on both rations, and the difference between them proved slight. The yield of milk per cow was 1.1 pounds less and of fat .02 pound less on the soybean hay ration than on the alfalfa hay ration. Furthermore the cows did not maintain their weights quite as well on the soybean hay ration. These results were probably due to the fact that the cows actually consumed less of the soybean hay than of alfalfa. Before drawing any definite conclusion concerning the relative value of the two kinds of hay, it will be necessary to continue the investigations further. This trial shows, however, that soybean hay is excellent for dairy cows, even though not quite equal to alfalfa—the best of all legume hays for milk production.

Alfalfa Versus Clover Hay for Fattening Cattle

ON ACCOUNT of the popularity of alfalfa hay as a feed, its relative value compared with that of red clover hay is a question of much interest. Comparisons of these two kinds of legume hay have been made in recent years at the two corn-belt stations. The conclusion was reached that alfalfa hay was not superior to red clover hay of equal quality for fattening beef cattle. These trials were not, however, so planned that advantage was taken of the fact that alfalfa hay is much richer than clover hay in digestible crude protein. On the average 100 pounds of alfalfa hay furnishes 10.6 pounds digestible crude protein, while red clover hay supplies only 7.6 pounds. Therefore, less expensive protein-rich supplement, like cottonseed or linsed meal, is needed to balance the ration with alfalfa hay than when red clover hay is fed. Yet in these experiments carried on elsewhere the same amounts of supplement were given to the alfalfa-fed steers as to those fed clover.

This past winter a comparison of the value of these two kinds of hay for fattening cattle was made by Messrs. Fuller and Morrison in which the amount of protein-rich supplement (cottonseed meal) was so adjusted that both rations furnished the same amounts of digestible crude protein. Two lots, each of 10 two-year-old grade Hereford steers, were fed experimentally for 120 days after a preliminary feeding period. The lot on clover hay received 6.0 pounds Wisconsin-grown red clover hay, 9.3 pounds ear corn, and 27.0 pounds corn silage. In addition 1.4 pounds cottonseed meal was needed to balance the ration. The alfalfa-fed steers received 6.0 pounds Wisconsin-grown alfalfa hay, 27.0 pounds corn silage, and 10.0 pounds ear corn. Only 0.8 pound cottonseed meal was needed to balance this ration on account of the higher protein content of alfalfa hay.

In this trial the alfalfa-fed steers gained 2.26 pounds a head daily and those receiving clover 1.88 pounds, and the alfalfa-fed steers sold for 10 cents more a hundredweight. Further experimental work will be necessary to determine definitely the relative value of these two kinds of hay when fed so as to gain advantage from the high protein content of alfalfa. These results indicate, however, that in beef cattle feeding, just as in feeding dairy cattle, alfalfa hay is more valuable than clover, primarily due to its higher protein content.

Increasing Efficiency of Swine Rations

MANY WISCONSIN pork producers are fortunate in having plenty of dairy by-products available for their pigs. Where there is plenty of skimmilk, buttermilk, or whey for feeding, there is little need of purchasing commercial protein-rich feeds, such as tankage (also called meat meal), linseed meal, or wheat middlings. For the benefit of those who do not have a sufficient supply of dairy by-products for swine feeding, a series of trials is being conducted by Messrs. Morrison and Fargo to compare the various protein-rich supplements for growing and fattening pigs.

Poor results are secured when either linseed meal or wheat middlings is used as the only supplement to corn or barley for pigs which are not on pasture. This is because such rations supply protein of poor quality and furthermore are low in lime. Somewhat better results are secured when linseed meal or wheat middlings is used as the only supplement for pigs on good pasture, but even then such a ration is not economical. In three different trials pigs fed corn and linseed meal on good pasture gained on the average 1.17 pounds a head daily and required 420 pounds concentrates for 100 pounds gain. Similar pigs fed corn and tankage gained 1.34 pounds a head daily and required only 393 pounds corn and tankage per 100 pounds gain. Compared with tankage at $60 a ton, linseed meal was actually worth only $17.56 a ton in these trials, though it usually costs over three-fourths as much a ton as tankage.

However, surprising results have been secured when a mixture of half tankage and half linseed meal has been fed as a supplement to corn for pigs on good pasture. In five separate experiments, pigs fed this mixture on good pasture have gained 1.43 pounds a head daily on the average and required 370 pounds feed for 100 pounds gain. Other lots fed corn and tankage gained on the average 1.36 pounds a day in these five trials and required 16 pounds more feed for each 100 pounds gain. Though linseed meal was worth only $17.56 a ton compared to tankage when fed as the only supplement, when linseed meal was thus combined with tankage it was actually worth over $92.00 a ton.

A mixture of corn germ meal (germ oil meal) and tankage has been recommended by some as a protein-rich mixture for swine feeding. However, in two trials the combination of corn germ meal and tank-

age has proven decidedly less efficient to feed with corn for pigs on pasture than the mixture of linseed meal and tankage.

Although this mixture of linseed meal and tankage is so highly efficient for pigs on good pasture, it is not as satisfactory for pigs fed in dry lot. For winter feeding the combination mentioned in the report for the previous year continues to prove highly efficient. This is a mixture of 50 pounds tankage, 25 pounds linseed meal, and 25 pounds chopped alfalfa. In eight different experiments pigs fed this combination as a supplement to yellow corn in dry lot have gained 1.16 pounds a head daily while those fed only yellow corn and tankage gained only 0.97 pound and required 20 pounds more feed for each 100 pounds gained. This protein-rich mixture has thus far been the most efficient of any of the numerous combinations tested which did not include any dairy by-products.

Rations for Brood Sows

Does Corn Hurt Brood Sows? On account of its cheapness, corn is the chief grain fed to sows throughout the corn belt. Due undoubtedly to the poor results secured when corn is unwisely fed to brood sows without proper protein-rich supplements, several writers have gone so far as to state that corn should not form over one-third to one-half the ration for brood sows, as it is "too fattening." However, experiments carried on by Messrs. Morrison, Bohstedt, and Fargo show clearly that excellent results are secured when corn is the only grain, if it is properly supplemented and provided the allowance is strictly limited to the amount needed to keep the sows in thrifty condition, without becoming too fat.

In three trials with gilts a concentrate mixture which many breeders would consider about ideal was compared with the more simple ration of ear corn, alfalfa hay fed in a rack, and 0.3 pound tankage per head daily in addition. The concentrate mixture consisted of 35 parts ground corn, 30 parts ground oats, 30 parts wheat middlings, and 5 parts tankage.

On the average, the gilts required 5.5 pounds of this mixture per head daily to keep them making the desired gain of about 0.9 pound a day, while the other lot made trifle larger gains on 4.5 pounds corn (reduced to the basis of shelled corn), 0.3 pound tankage, and 0.4 pound alfalfa hay. Thus the gilts fed ear corn properly supplemented required 0.3 pound less feed per head daily, which would be expected from the fact that corn is a more concentrated feed and richer in net energy than oats or middlings. With feeds at usual corn-belt prices, the daily cost of feed per sow was 30 per cent less on this ration. Still more important was the fact that the farrowing results were even a trifle better than on the ration which contained only 35 per cent of corn.

Legume Hay and Corn. A ration of only legume hay and grain is quite satisfactory for brood sows, especially for yearlings or older

sows. Gilts had best receive a small amount of a protein-rich concentrate in addition, such as tankage, skimmilk, buttermilk, linseed meal, or wheat middlings. This is shown by trials carried on during four winters. Each winter one lot of gilts was allowed access to good alfalfa hay in a rack and fed in addition enough ear corn to make the desired gains. Another lot was fed similarly except that they were given in addition one-quarter to one-third pound of tankage per head daily.

On the average the gilts fed tankage in addition to ear corn and alfalfa hay made somewhat larger gains. Also the average weight of the pigs at birth and the proportion of vigorous pigs were greater with this ration. Thus from all standpoints it was advisable under corn-belt conditions to add a small amount of a protein-rich concentrate to the ration of corn and alfalfa hay.

Roots for Brood Sows. Many swine breeders provide roots as a succulent feed for their brood sows in the winter. Without question, roots are a desirable addition to the ration of brood sows when no legume hay is fed, for they are palatable, bulky, and laxative. However, roots will not take the place of legume hay, for they are not rich in protein and calcium.

To find whether there was any advantage in adding roots to well-balanced rations, including alfalfa or clover hay for brood sows, experiments have been carried on during four winters. Either sugar-mangels or yellow carrots were added to a ration of corn, tankage, and alfalfa hay or a ration consisting of clover hay and a concentrate mixture of barley, oats, wheat middlings, and linseed meal. Gilts, yearlings, and aged sows were used in the various trials. Contrary to what many experienced swine breeders would predict, in no case did the addition of roots to these rations result in larger or more thrifty pigs. Furthermore, roots proved to be decidedly uneconomical under corn-belt conditions, for in no case was their actual feeding value as high as $4.00 per ton with corn at 56 cents a bushel and other feeds at corresponding prices.

Do Brood Sows Fed Good Rations Need Mineral Supplements?

AMONG THE livestock questions most frequently discussed is that of the feeding of mineral supplements or mineral mixtures to animals. It is well known that when swine are fed well-balanced rations on such good pastures as alfalfa, clover, or rape, excellent results will usually be secured without the addition of any mineral supplement whatsoever, except common salt. Whether still better results will be secured if a mineral supplement supplying calcium or both calcium and phosphorus is added to the ration is a matter of much importance.

To study this question two extensive experiments have been carried on with brood sows by Messrs. Morrison and Fargo. To make the trials as conclusive as possible, they did not include merely the period

when the sows were pregnant. Both experiments were started in early summer with gilts (sow pigs) weighing 60 to 70 pounds. These were divided into uniform lots, each of 12 pigs the first year, and 10 pigs the second year.

Each year one lot of gilts was fed a well-balanced concentrate mixture of corn, oats, wheat middlings, linseed meal, and tankage, with no mineral supplement, except common salt. During the summer they were on pasture and during the winter they had access to good alfalfa hay in a rack. This check lot was, therefore, fed merely a modern, efficient ration, made up of ordinary feeds, and just such a ration as progressive breeders are recommending everywhere. In the first experiment alfalfa pasture was used, and the second year the pasture was blue grass.

In each experiment another lot of gilts (Lot II) was fed just the same as Lot I, except that two pounds of steamed bone meal were mixed with each 100 pounds of their concentrate mixture. A third lot (Lot III) received ground limestone instead of steamed bone meal.

Each year throughout the pasture season there was no advantage whatsoever from adding either steamed bone meal or ground limestone to this good ration. Likewise in the winter the gilts fed these mineral supplements made no more rapid nor more economical growth than Lot I, fed neither of the mineral supplements.

The most important part of such an experiment comes at farrowing time, for there might be a difference in the vigor of the offspring, even though the sows themselves showed no difference in growth or cost of gains. However, both in the trial carried on last year and in the trial just now being completed there has been no evidence of the pigs being any larger, or more thrifty, or having better bone or longer bodies when their dams had been fed steamed bone meal or ground limestone. These experiments, therefore, show clearly that there is no advantage in adding a mineral supplement such as steamed bone meal or ground limestone to the efficient, well-balanced ration fed these gilts, which included tankage.

When for any reason it is necessary to feed a ration low in lime to swine, then this mineral should be furnished by adding a mineral supplement. Wherever there has been trouble from hairless pigs, iodine should be added to the ration of the pregnant sows to prevent this disease. There is, however, no conclusive proof that there is any benefit derived from adding iodine to the rations of any except pregnant sows.

Lime (calcium) can be supplied very cheaply by using finely ground limestone, air-slaked lime, chalk, or wood ashes. When there is a possibility of phosphorus being lacking as well as calcium, it is best to supply both these minerals in such forms as steamed bone meal, spent bone black, or ground rock phosphate. Other ingredients are also often incorporated in mineral mixtures, especially charcoal, sulfur, Glauber's salts (sodium sulfate), Epsom salts (magnesium sulfate), and copperas (iron sulfate). There is no conclusive evidence to show

that there is any benefit from giving such ingredients to an animal which is thrifty and making normal gains.

So far as is definitely known, simple home-prepared mineral mixtures give just as good results as expensive proprietary preparations some of which cost $150 a ton or more.

Swine Abortion Studies

THE STUDY of infectious abortion of swine by F. B. Hadley and B. A. Beach (Veterinary Science) has been in progress this past year on an experimental herd of 23 sows and 2 boars. The hogs were divided for study into six lots and were treated to learn more about (1) means of stimulating the production of immunity and (2) paths by which the causal germ *(Bacterium abortus)* enters the body of the animal.

A blood sample was first taken from each hog to test it for evidence of abortion infection. No trace of infection could be demonstrated.

Lot 1 was used to determine the nature of immunity that develops after vaccination with living abortion bacilli administered subcutaneously (under the skin.)

Lots 2 and 3 were designed to study the various reactions that occur following vaginal introduction of living abortion bacilli after and before service respectively.

Lots 4 and 5 comprise animals that were selected to learn whether abortion infection could be acquired through environmental contacts alone.

Lot 6 was injected intravenously (into the vein) with living abortion bacilli during pregnancy.

Work involving farm livestock with long gestation periods must of necessity be continued over a period of years before data are available from which even tentative conclusions can be drawn. The year's work so far shows:

1. The subcutaneous and intravenous injection of living abortion bacilli (vaccine) in open sows and gilts in the majority of cases apparently resulted in no permanent injury.

2. This vaccination treatment enabled both open sows and gilts to withstand the effects of large doses of abortion germs after they were bred.

3. Swine usually, but not always, react to the agglutination test following subcutaneous and intravenous injections of living abortion bacilli.

4. It is possible for some sows to become infected by way of the vagina after the uterine seal has formed, but judging from these experiments, infection by this path after conception has taken place does not occur frequently.

5. Experimental gilts were infected by vaginal introduction of abortion bacilli before pregnancy.

6. The establishment of infection in non-pregnant sows is more difficult than in pregnant ones.

7. Sows become infected most readily per vagina at or near the time of service.

8. Most of the sows and gilts experimentally infected with living abortion bacilli failed to react to the agglutination test after the lapse of four months. This shows that the danger of establishing permanent infection carriers by vaccination is not great.

9. After the subcutaneous and intravenous injection of living abortion bacilli a small per cent of sows and gilts failed to conceive even though served repeatedly.

Hernias in Swine

SINCE hernias in swine are quite common and considerable loss results from them, B. L. Warwick (Veterinary Science) has attempted to ascertain their relative prevalence.

To this end, the swine in the University Farm herd were closely observed from March 1, 1922, to August 15, 1923. Of the 1,008 pigs raised during this time, 38, or 3.77 per cent, had hernias; 6.3 per cent of the 471 male pigs raised were affected.

Of 59 pigs raised from sows sired by a boar afflicted with hernia, 8.5 per cent of the progeny developed it. Of 32 male pigs raised in this group, 15.6 per cent showed this defect.

Tuberculosis in Cattle and Swine

NO MORE important livestock disease problem affects the Wisconsin stockman than that of tuberculosis. It will be a constant fight to hold down the spread of this disease, but in a state where the breeding interests are so dominant it must be done. The interrelations of this disease in cattle and hogs is of the greatest importance.

Tuberculosis in Swine. Figures compiled from the Federal Bureau of Animal Industry inspectors' reports at the five largest packing plants in Wisconsin between October, 1922, and July, 1923, show that nearly 25 per cent, or 351,008 animals out of the 1,496,000 hogs slaughtered, were infected with tuberculosis. Most of the diseased hogs came from farms located in the south half of the state.

For several years B. A. Beach (Veterinary Science) and E. G. Hastings (Agricultural Bacteriology) have been investigating the type of organism found in tuberculosis of swine to see if such cases could be traced to avian or bovine origin. A study of the specimens from 15 hogs showed that two of the organisms isolated were of avian or fowl type, while the remaining 13 cases were of bovine origin. If tuberculosis in swine may be produced from fowls, the eradication of the disease in the dairy herds may not suffice to eliminate the disease from swine where infected poultry are allowed to exist.

Skin Lesions in Cattle. The finding of tuberculosis in the skin of cattle has been reported by veterinary inspectors of meats stationed

at the large packing centers. A study of 23 specimens of such material by bacteriologic methods failed to reveal any genuine tubercle bacilli of the bovine type, although acid-fast organisms were found in seven out of the 23 specimens. A question arises as to whether these were dead tubercle organisms or a non-disease-producing acid-fast organism.

Tuberculosis in Horses. Last May the lungs and liver of a ten-year-old horse were sent to the Experiment Station for diagnosis by a veterinarian in New Glarus. A microscopic examination of the specimen revealed numerous acid-fast organisms; inoculations with these organisms caused the death of guinea pigs. Numerous tubercles were found in the liver and spleen, which upon examination by Mr. Beach were shown to be undoubted tubercle organisms. This case is of special interest on account of the rarity of this disease in horses.

Johne's Disease Spreading in Wisconsin

THE SLOW and insidious Johne's disease of cattle is gradually becoming more or less widespread, not only in Wisconsin, but throughout the United States, and is apparently far more prevalent than was formerly supposed. Data and material for study have been received from twenty veterinarians in seven different states. The diagnosis of this disease can be definitely determined by the use of the new test fluid, Johnin. This station has made special effort to prepare and send this material to applying veterinarians. Mr. Beach has tested 300 head of cattle in sixteen different herds. Of this number he has found seven, or 2.3 per cent, which reacted to the Johnin indicating disease infection. Only two of these herds had been tested before.

From material which has been sent in to the laboratory for diagnosis, Johne's disease has been diagnosed eight times. All of these positive specimens were from Wisconsin cattle. As the traffic in pure-bred cattle increases, it is obvious that more attention must be paid to this disease, and the farmer and stockman cannot afford to ignore it. Its slow progress and insidious nature does not readily alarm the owner as would be the case with a more acute disease.

Control of Contagious Abortion in Cattle

CONTINUED investigations during the year by Mr. Hadley tend to show that the abortion vaccine, a preparation containing living abortion germs, is of real value as an immunizing agent when properly prepared, injected while fresh, and employed according to directions. During the year, 270 doses of this material were prepared and sent to cooperating veterinarians for field use. Practically all of this vaccine was employed in herds where the disease had already secured a foothold for the purpose of protecting cows that had not yet become infected with the disease. Reports from users of the product indicate that it is helpful in controlling the spread of this dreaded disease.

Extensive use is also being made of the station's facilities for the testing of bovine blood samples to detect abortion infection. Exactly 2,400 such samples were tested during the past year. Among them were samples from cattle owned by the Cedar Rapids Bull Association where the community cooperates in safeguarding the herd by having the cattle in all herds tested before being allowed the use of the association sire. Since reacting animals are required to be disposed of, this system goes a long ways toward preventing the bull from becoming infected with or acting as a mechanical carrier of the abortion disease. Results obtained by this organization indicate that the blood test is an effective measure for the control of abortion disease in a community breeding association and that the measure is practicable. The experience points the way to the possibility of establishing abortion-free accredited herds, somewhat after the method now so widely employed in the tuberculosis-free accredited herds used in the control of that diseases.

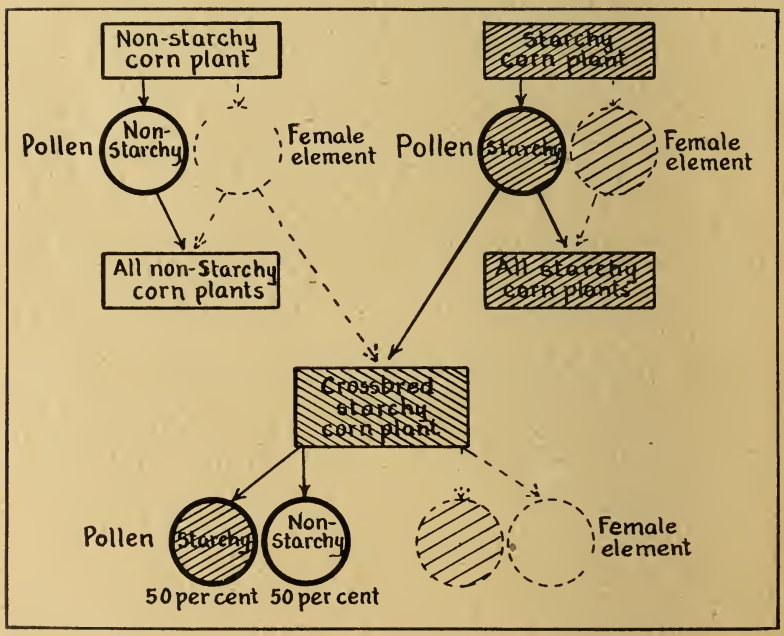


FIG. 40.—INHERITANCE OF THE STARCHY AND NON-STARCHY CONDITION IN CORN POLLEN

This is the first pollen character in corn of which the inheritance has been determined. The starchy and non-starchy conditions form a contrasted pair. Crossbred plants produce two types of pollen grains with equal frequency.

White Diarrhea in Poultry

THIS DISEASE in young chickens is purported to have been responsible for heavy losses in the poultry industry during past years. Mr. Beach and J. G. Halpin have tested the blood of about 1,000 birds on the station poultry farm for evidence of infection. Nearly 11 per cent of these fowls reacted to the agglutination test. The practical importance of this project makes it desirable to ascertain the manner of spread of the disease by further study.

Inheritance of a Pollen Character in Corn

STUDENTS of heredity have recently directed their attention towards the detailed processes by which seed is set in plants. The more prominent aspects have been familiar for many years. In corn, for example, the pollen, shed in abundance by the tassels, must fall upon the silks before grain can be formed on the cob. The pollen grains lodged on the silks germinate and produce tiny plants consisting of single slender filaments which push their way between the cells of the silk and eventually reach the undeveloped seed structure on the cob and initiate development of the seed. It is only recently, however, that these events have been made the subject of critical study from the standpoint of heredity.

Each pollen grain at the time it is shed from the tassel contains some food material which is utilized in the subsequent growth processes. In this respect it is similar to a seed which provides food for the seedling in its early stages of growth. Examination has been made of the food stored in the pollen of different varieties of corn by R. A. Brink (Genetics), and it has been found that it corresponds rather closely in its nature with the materials laid down in the seed itself. Races of corn which produce starchy seeds, and these comprise all the field types, bear pollen containing more or less starch. On the other hand, a strain obtained originally from China and termed "waxy" on account of the resemblance of the interior of the seed to hard wax contains no starch in these parts. It has been shown that the pollen also of this race lacks starch, this latter being replaced by a closely related substance, probably a dextrin.

The inheritance of the ability to produce starchy or non-starchy pollen has been determined. Plants which received the hereditary elements for starchy characteristics from both their parents will themselves produce only starchy pollen grains. Likewise, pure non-starchy plants of which the so-called Chinese waxy race consists, produce only non-starchy pollen. When the starchy and non-starchy types are crossed by applying the pollen of the one to the other, however, an interesting situation develops. The seeds immediately resulting from hypridization are starchy. The starchy character is dominant to the non-starchy condition. Plants grown from these crossbred starchy seeds, unlike those raised from seed from a pure starchy race, produce

pollen grains of two types and in equal numbers. One-half the pollen grains shed by these hybrids is starchy and the other half non-starchy. The transmission of this character is illustrated in Fig. 40. This is the first pollen character in corn the hereditary behavior of which has been determined.

PUBLICATIONS

The Experiment Station in 1922–23 published 11 popular bulletins and 8 reprints, and 5 research bulletins. Thirteen circulars and 8 reprints, and also 14 stencil bulletins were issued by the Extension Service.

The bulletins are listed below:

Popular Bulletins

Bulletin 345.—Why Costs of Milk Vary. (P. E. McNall and D. R. Mitchell.) Milk costs are necessary in order to determine profits or losses of the herd. Cow-testing associations are a possible source of milk cost figures.

Bulletin 346.—Marketing by Cooperative Sales Companies. (Theodore Macklin.) A study of the improvements in marketing brought about through the establishment and operation of sales companies and the possibilities for cooperation.

Bulletin 347.—Farming the Silt Loams of Central Wisconsin. (F: L. Musbach.) As heavy silt loam is the most important soil type in central Wisconsin, the management of this type brings up problems of special interest to farmers now in the area as well as to the new settler.

Bulletin 348.—Tobacco Wildfire in Wisconsin. (James Johnson and S. B. Fracker.) The disease of tobacco, known as wildfire, has shown itself to be sufficiently serious in other tobacco districts to warrant Wisconsin growers using all possible measures to prevent its occurrence in their fields.

Bulletin 349.—Make Alfalfa a Sure Crop. (R. A. Moore and L. F. Graber.) A discussion of the needs of the alfalfa crop which is assuming more and more importance as a Wisconsin crop.

Bulletin 350.—Minerals for Livestock. (E. B. Hart, H. Steenbock, and F. B. Morrison.) A discussion of the kind of minerals to feed and the amounts required by different classes of stock.

Bulletin 351.—An Outlet Drain for Every Farm. E. R. Jones and O. R. Zeasman.) State laws provide a means by which neighbors may cooperate in the construction and maintenance of an outlet drain serving a community; without such outlets many farm drains would be valueless.

Bulletin 352.—Science Serves Wisconsin Farms. Annual Report of the Director, 1921–1922. (H. L. Russell and F. B. Morrison.) A re-

view of results secured on the different experimental projects conducted at the Experiment Station.

Bulletin 353.—Farm Homes. (Departments of Home Economics and Agricultural Engineering.) Descriptions and plans of comfortable and convenient farm homes.

Bulletin 354.—The Modified Leader Tree. (R. H. Roberts.) The advantages of the modified leader tree and how trees should be pruned.

Bulletin 355.—Nicotine Dust Kills Cucumber Beetles. (John E. Dudley, Jr., H. F. Wilson, and W. D. Mecum.) Nicotine dusts have been found most effective in killing the cucumber beetles.

Research Bulletins

Research Bulletin 52.—The Development and Winter Injury of Cherry Blossom Buds. (R. H. Roberts.) A study of the variation in relative hardiness of the blossom buds found in various types of fruit-producing plants.

Research Bulletin 53.—The Influence of Soil Temperature on Potato Scab. (L. R. Jones, H. H. McKinney, and H. Fellows.) Trials were undertaken in both field and greenhouse to determine the influence of soil temperature on the development of the common scab of potato.

Research Bulletin 54.—The Value of Lime and Inoculation for Alfalfa and Clover on Acid Soils. (E. J. Graul and E. B. Fred.) Frequently the growth of alfalfa and, in some cases, of clover is largely determined by the amount of lime in the soil and the presence of the proper nodule-forming bacteria.

Research Bulletin 55.—An Experiment Study of Infectious Abortion in Swine. (F. B. Hadley and B. A. Beach.) A study of the cause of infectious swine abortion, the relationship between infectious abortion in cattle and swine, the mode of transmission, the incubation period, the period of communicability, and the means of control.

Research Bulletin 56.—Effect of Defoliation Upon Blossom Bud Formation. (R. H. Roberts.) Tests were made of the effect of varying types and amounts of defoliation upon blossom bud formation in species of American plums.

Technical Articles

Much of the technical scientific output of the experiment station staff is first presented to the scientific public through the medium of the science periodicals and publications of scientific societies. The publication of such matter enables our workers to have their results scrutinized by their scientific colleagues. The following articles have been published during the past year, ending June 30, 1923:

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Bryan, O. C. The effect of different reactions on the growth and calcium content of oats and wheat. Soil Science. *15*:375–381. 1923.

Bryan, O. C. Effect of reaction on growth, nodule formation, and calcium content of alfalfa, alsike clover, and red clover. Soil Science. *15*:23–35. 1923.

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Cole, L. J. The "Chantecler." A new breed of poultry—developed to meet the winter conditions of the north. Journ. Heredity. *13*:147–152. 1922.

Cole, L. J., and Steele, D. G. A waltzing rabbit. Jour. Heredity. *13*:290–294. 1923.

Dickson, J. G., Eckerson, S. H., and Link, Karl P. The nature of resistance to seedling blight of cereals. Proc. Nat. Acad. Science. v.9. 1923.

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Duffee, F. W. Report of Silage Cutter Tests. Am. Society Agr. Engineers Trans. 1923.

Fred, E. B., Peterson, W. H., and Anderson, J. A. The fermentation of arabinose and xylose by certain aerobic bacteria. Jour. Bact. *8*: No. 3. 1923.

Fred, E. B., Peterson, W. H., and Anderson, J. A. Production of acetone, alcohol, and acids from oat and peanut hulls. Jour. Indust. and Engin. Chem. *15*:126. 1923.

Graber, L. F. Scarification as it affects longevity of alfalfa seed. Jour. Am. Soc. of Agron. *14*:298–301. 1922.

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Hastings, E. G., Davenport, Audrey, and Wright, W. H. The influence of certain factors on the methylene blue reduction test for determining the number of bacteria in milk. Jour. of Dairy Science. *5*:5. 1922.

Hastings, E. G. Wisconsin Experiments with cheese. Proc. Twenty-third Annual Convention Southern Wis. Cheesemakers' and Dairymen's Assn. 1923.

Hibbard, B. H. The effect of freight rates on agricultural geography. Jour. Farm Econ. *4*:129. 1922.

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THE WISCONSIN AGRICULTURAL EXPERIMENT STATION, IN ACCOUNT WITH THE UNITED STATES APPROPRIATION

1922-1923	Dr.	Cr.
To receipt from treasurer of the United States, as per appropriation for the year ending June 30, 1923, under the acts of Congress approved March 2, 1887, and March 16, 1906	$30,000.00	
By salaries		$20,774.54
By labor		5,605.05
By publication		122.51
By freight and express		3.22
By chemicals and laboratory supplies		1,186.36
By seeds, plants, and sundry supplies		500.95
By fertilizers		33.43
By feeding stuffs		822.85
By tools, machinery, and appliances		4.50
By scientific apparatus and specimens		790.00
By livestock		36.00
By traveling expense		111.59
Total	$30,000.00	$30,000.00

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF WISCONSIN
STATIONS
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+ COUNTY REPRESENTATIVE

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Bulletin 363 April, 1924

Farm Orchards

AGRICULTURAL EXPERIMENT STATION OF THE
UNIVERSITY OF WISCONSIN, MADISON

Digest

A farm orchard to be worth while must be properly managed and cared for. An orchard which is started and then left to take care of itself will never become a source of pride or of much good fruit. Page 3

Choose the orchard site carefully. A tract with a soil adapted to a wide range of fruits, slightly elevated and located near the house is preferable. Pages 3-5

Hardiness is the first consideration in selecting varieties. A farm orchardist may experiment with new and untried varieties, but the greater part of the planting should be of standard varieties adapted to the particular section. Pages 10-12

Good care of the trees before planting, careful planting, and proper pruning after planting are absolutely necessary if satisfactory results are to be secured. Pages 13-18

The system of soil management should be adapted to the character of the site. On lands level enough to cultivate, the tillage-cover crop system is probably best. Cropping with cultivated crops is permissible in a young orchard if care is exercised not to injure the plants either temporarily or permanently. Never use a young orchard as a pasture. Pages 18-20

The average farm orchard which has been bearing for some time needs fertilizer. Manure or commercial fertilizers which supply nitrogen are usually most beneficial. Best results in fertilization can only be attained when the orchardist makes a careful study of the performance of his trees. Lack of fruitfulness may result either from too much or too little vegetative, (twig and branch) growth. Page 21

Neglect of pruning means trouble later on. Pruning should start as soon as the tree is planted and should be done annually during the life of the tree. Alternate neglect and spasmodic pruning results in a poorly formed and less productive tree. Pages 22-27

Spraying is necessary to the production of good fruit and healthy trees. It is a preventive, not remedial. Only effective spraying is worth while. It is effective only when the proper materials are thoroughly applied at the proper time. Have a spraying program and follow it persistently unless you are sure that you can improve upon it. Page 28

If your orchard is too small to warrant the purchase of a power sprayer consider the advisability of organizing a "spray ring" among your neighbors who are similarly situated. Orchard pest control in small orchards will be more efficient and less expensive in a "spray ring" than when done by the individual orchardist. Page 33

Farm Orchards

James G. Moore

A MAJORITY of the farm orchards in Wisconsin are money losers. For the most part they are left to care for themselves and forced to compete with other crops for their food and moisture. Under such conditions they will not be sources of profit nor produce good fruit for use in the home.

To be profitable, orchards must be properly cared for from the time the trees are received from the nurserymen. Often a grower does not

Successful Orchard Culture Demands

A soil adapted to the fruit grown.
Planting of hardy varieties.
Care in planting.
An adapted and thorough system of soil management.
Pruning which conserves the energies of the tree and lightens the orchard work.
Spraying of a character which will control the pests and make the fruit edible and salable.

know what are the best ways of managing an orchard. This bulletin treats briefly of practices of orchard management which seem best suited to give best returns from the farm orchards of this state.

Select Orchard Site With Care

Four things need consideration in selecting the site for a farm orchard: convenience, soil, elevation and exposure. Convenience is the first, for unless the orchard is located at least fairly close to the house its care is almost sure to be neglected and poor utilization is made of the fruit that is produced. Convenience should take precedence over all the other considerations except soil and it may make it desirable in some cases to select a site with a somewhat less favorable soil than one which is not conveniently located, but with more favorable soil.

Soil, of course, is very important for without reasonably favorable soil conditions failure is sure to result. While various fruits seem to prefer somewhat different types of soil, type of soil is not of so much importance to the farm orchardist as some other soil conditions. Usually the farm

orchardist wishes to grow a number of kinds of fruit. In fact, he should grow all the kinds which can be grown with reasonable success in his section. A soil suited to grow reasonably well a number of kinds would then be preferable to one especially adapted to one kind. When available, a heavy sandy loam, gravelly loam, or light clay loam soil would be a desirable type for a farm orchard.

There are other considerations in selecting a soil of even greater importance than surface soil type. The kind of subsoil is often a controlling factor in selecting a site. When the subsoil comes close to the surface it is

FIG. 1.—A NEGLECTED FARM ORCHARD
With proper care this orchard would produce good crops.

important that it be such as will allow free development of the root system of the trees and the ready escape of excessive soil moisture. An open, gravelly subsoil, containing some clay or a pervious limestone meets the requirements of an orchard. The subsoil should not be so porous as not to hold soil moisture reasonably well. A favorable soil depth including surface and subsoil of at least four or five feet is desirable. A site with unbroken rock or hardpan within three feet of the surface should be avoided.

Good soil drainage is imperative. The site should be studied in this regard beyond mere consideration of the slope of the surface. Not infrequently sites with good surface slope have poor soil drainage. If the site has favorable subsoil, the danger of poor drainage is largely overcome, but even then attention should be given to the presence of small potholes, or seepage from higher elevations.

Physical condition and fertility should be given attention in selecting a soil. It is desirable that the soil have good tilth and abundant fertility. If other conditions are favorable a soil which does not possess these characteristics may be chosen providing these deficiencies can be corrected.

Elevation Reduces Frost Injury

There is always a possibility of damage from late spring frosts during the flowering period and orchards on low land suffer first. An elevated orchard site does not mean that it must be the highest piece of land in the vicinity, but rather that it should have lower levels near it. A site on a slope, if it is not so steep as to cause soil erosion, is preferable to a level one.

It is no advantage to have the orchard on an elevated site unless there is opportunity for air drainage. "Frost pockets" caused either by forests or lay of the land should be avoided.

No One Exposure Best Under All Conditions

Exposure is the direction of slope of the site. On rolling sites it is impossible to have all land slope in the same direction, but in such cases the general slope is considered.

It is important that the orchard be protected in sections in Wisconsin subject to strong, dry, cold winds during the winter. An exposure away from the prevailing winter winds is desirable. Exposure also is important as regards winter injury. A northerly exposure is much preferred in this regard. As a rule, in this state a northern or northeastern exposure is best. Near large bodies of water an exposure towards the water is usually advantageous.

Most farm orchardists will find it impossible to secure on their farm sites which are ideal. In such cases the aim should be to approach as near the ideal as possible, laying the greatest emphasis on convenience and soil.

Most Farm Orchards Are Too Large

The farm orchard should supply an abundance of fruit for the home. In doing this there will be times when a surplus will be produced, but the farm orchardist should not attempt to produce fruit for market. Many farmers in Wisconsin will doubtless find it desirable to plant orchards to produce fruit for market as a distinct part of their farm operations, but in such cases their orchards should be planned very differently from those designed to produce fruit for the home. A tract 115 by 200 feet, well chosen, planted with adapted varieties, and given the proper care will produce, when in moderate bearing, more tree fruit than can be used in the average home.

Under the varying conditions in Wisconsin, it is not possible to make a plan which will apply possibly even in a majority of cases. The following plan (Fig. 2) is suggestive only and will need modification to fit local conditions. In cases where pears or cherries cannot be grown they may be replaced by apples or small fruits or the size of the orchard may be reduced.

Thoroughly Prepare the Ground for Planting

The character of the surface soil and the subsoil should be considered

when preparing ground for planting. The surface soil should be considered from two standpoints—the character of the tilth and the presence of organic material. While the former is more or less dependent upon the latter, the degree of fineness is a matter that should not be overlooked.

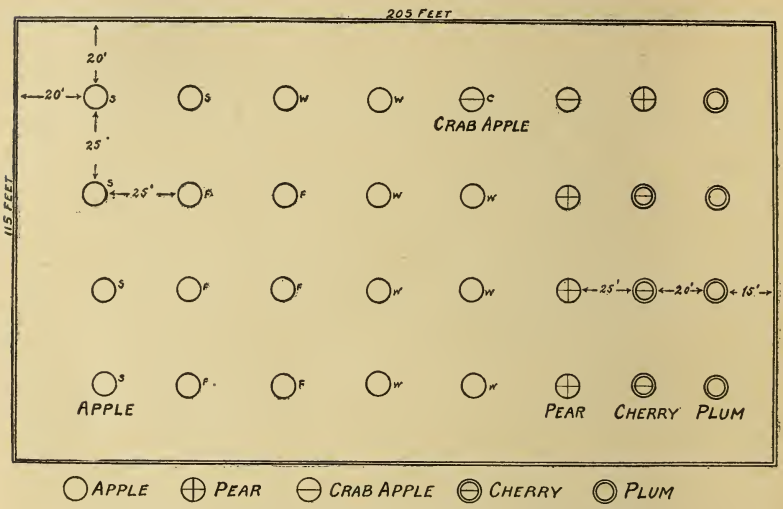

FIG. 2.—A SUGGESTIVE PLAN FOR A HOME ORCHARD
Most home orchards are too large.

A good method is to plow under a clover sod, or still better, a crop of clover, and follow it with a cultivated crop, preferably corn. This puts the soil in the best possible condition for the planting of the trees the following year. Cultivate the crop frequently so as to put the soil in good tilth. The clover which has been turned under adds both organic matter and nitrogen which assists in a vigorous growth of the trees the season planted. If the soil has been put in good condition, little work is necessary in the spring before planting. The land may have been plowed the fall previous or just before planting. Fall plowing usually permits earlier setting of trees. A couple of discings or harrowings just before planting puts the soil in fine condition to receive the trees, although this is not absolutely necessary before planting.

A porous subsoil will need no attention, but if it is compact and comes close to the surface it should be broken up. The common methods of doing this are by subsoiling or dynamiting. On sites two steep for tillage practically nothing can be done in preparing the soil for planting.

The Square Is the Simplest System

There are a number of systems of planting orchards, but the one commonly used for farm orchards is the square. In this system the trees are planted at the four corners of a square. The equilateral triangle

system, sometimes called the hexagonal, permits of about 15 per cent more trees to the acre without reducing the shortest distance between the trees.

Give the Trees Lots of Room

The orchardist seldom makes the mistake of setting his trees too far apart. The trees in probably 90 per cent of the farm orchards in Wisconsin are set too close. Figure 4 shows the result. This orchard will never be productive and it is physically impossible to properly care for the fruit that is produced. There is only one remedy for orchards set as close as this one: Take out every other tree when they begin to interfere. The orchard illustrated has long since passed the time when this treatment would have been effective. It is really better for the farm orchardist to give more space than is really needed than to plant too close.

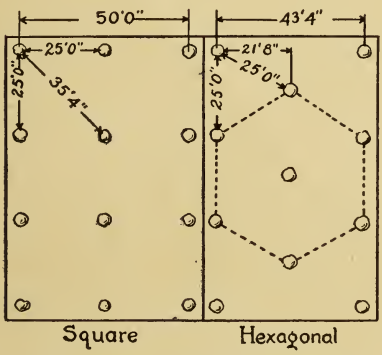

FIG. 3.—GOOD PLANTING PLANS

The square is more popular for farm orchards.

The following distances are suggested for farm orchard planting under Wisconsin conditions: Apples, not less than 25 feet, and in many instances 30 feet will be found preferable; plums, 16 to 20 feet; cherries, 20 feet; pears, 20 to 25 feet, depending on the characteristic growth of the variety.

Fillers Are Not Recommended

There is a considerable area unused by the trees in a newly set orchard. One of the methods devised for using this area is to plant temporary or filler trees. These fillers are earlier bearing kinds of fruit or earlier bearing varieties of the same kinds. The fillers are left until they begin to crowd the permanent trees, when they should be removed. It is doubtful whether their use should be recommended for Wisconsin, as in most cases some other method of utilizing this area will be more advantageous.

Locating the Trees

There are many methods of determining where the trees are to be set. The following will usually be found satisfactory when trees are to be set

in squares. Lay out base lines along one end and one side at the desired distance from the fence, usually not less than 20 feet, and at right angles to each other. Set stakes along these lines at intervals equal to the distance between trees. Fasten two wires equal in length to the distance between trees to a piece of iron in the form of a right triangle. The triangle and free ends of the wire should be fitted with rings for convenience in handling. (See Fig. 5.)

FIG. 4.—DO NOT PLANT TOO CLOSE
Close planting causes trees to grow like these.

To locate the remaining trees, hold the free ends of the wire at one side and one end stake, and set a third stake, marking the location for the next tree, in the corner of the triangle. Using the newly set stake and one previously set, other trees may be properly located. It requires three men to operate this device. On sloping areas, the wires should be kept horizontal and the place for setting the stake located by means of a plumb-bob suspended from the triangle.

For locating trees in the hexagonal system, the method is the same as for the square except that it is only necessary to set stakes along one end or side and that three wires of equal length are fastened together to

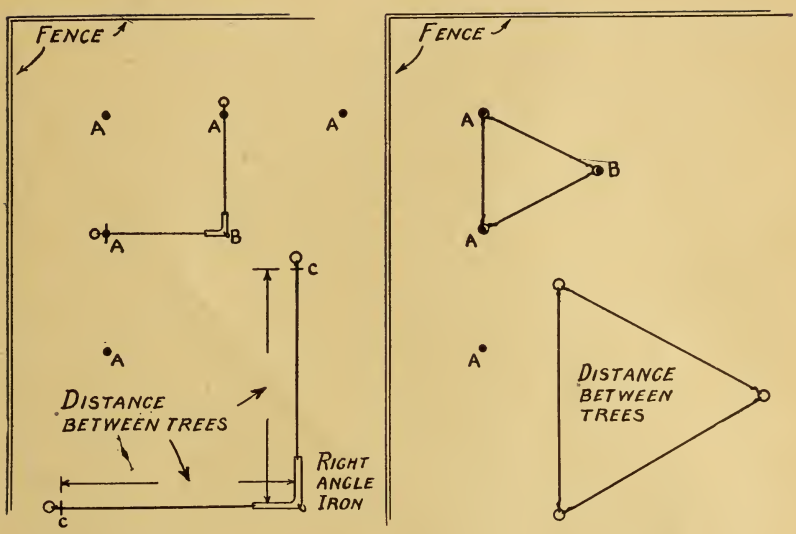

FIG. 5.—CONVENIENT METHODS OF LOCATING TREES

The figure on the left shows the method of planting in rectangles; right, for planting after the hexagonal plan. The letter A represents stakes marking the location of border trees and B stakes marking the positions of other trees located by use of rings and wires.

form a triangle with sides of equal length. Or two wires of desired length fastened to a piece of iron forming an angle of 60 degrees may be used.

Plant Only Good Trees

It is a waste of time to plant poor trees. Cheap trees are often the most expensive in the end. Therefore, one should be willing to pay enough to get good trees and then insist upon having them.

Best results will usually be had by planting well developed one-year-old trees, particularly of those kinds which branch the first season as cherries. Apples may be planted at two years, but most commercial orchardists prefer to set them at one year. Young trees are cheaper, transplant easier, permit of developing the top at the desired height, and give greater freedom in selecting foundation branches. The only disadvantage urged against them is that it requires a little more time for them to come into bearing. The advantages, however, more than offset this disadvantage.

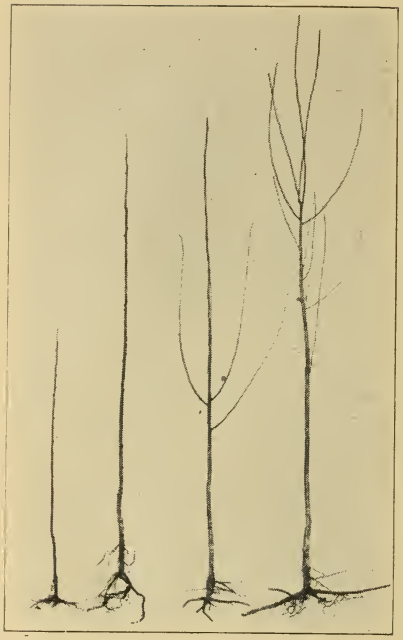

FIG. 6.—TYPES OF NURSERY TREES

From left to right—small one-year-old; exceptionally large one-year-old; good two-year-old; three-year-old (all apples). One and two-year-old trees are preferable for planting. They offer greater opportunity to shape the top as desired.

How to Order Trees

It is advisable to order trees directly from the nurseryman and to deal with a firm known to be responsible so in case the shipment is not satisfactory, adjustment is easily made.

The order should be placed early. By doing so you are much more likely to get the varieties you want. If ordering trees over one-year-old, state definitely size and age of tree desired. It is a good plan to keep a copy of the order. It will be convenient in checking up the trees and help to avoid disputes.

The order should state that substitutions are not allowed. Unless this is done the nurseryman may feel at liberty to substitute in case he is short of anything in the order.

Select Adapted Varieties

Hardiness is the principal thing to consider in selecting varieties for the home orchard. Owing to the peculiar geographical features and the varying climatic conditions in different parts of Wisconsin, it is practically impossible to give varieties equally adapted to the various sections. The accompanying map and list of varieties show in a general way the varieties which may be expected to be reasonably satisfactory for home orchard planting. In some localities in which conditions are more favorable than is generally found in that section, the varieties suggested for a section with less rigorous climatic conditions may give good results.

Suggested Varieties for Wisconsin Home Orchards

In all cases varieties hardy in the northern part of the state will be hardy in a southern section. However, because better varieties frequently

may be grown in the southern sections than certain of those recommended for the northern section, it is not always best to select a variety simply because it is hardy. Figures in the lists refer to divisions on the map.

FIG. 7.—FRUIT ZONES OF WISCONSIN

It is possible to divide the state into such zones only in a general way.

Apples

Summer:

1-2 Charlamoff, Yellow Transparent, Lowland Raspberry, Tetofsky, Oldenburg (Duchess).

3-4 Same as above also Red Astrachan.
On account of its susceptibility to fire-blight, Yellow Transparent should probably be omitted.

Fall:

1- Patten Greening, Longfield, Okabena.

2- Dudley, Fall Orange, Fameuse, McIntosh, Plumb Cider, St. Lawrence, University, Wealthy, Wolf River.

3-4 Bailey Sweet, Golden Sweet, Twenty-ounce.

Winter:

1- Malinda.*

2- Delicious, Golden Russett, Northwestern Greening, Salome, Talman Sweet, Windsor.

3- Grimes Golden, Jonathan, Northern Spy, Stark, Wagener, Winter Banana, Westfield (Seek-no-further), Willow Twig.

4- Hubbardston, King, Sutton Beauty, Stayman Winesap.

Crab apples in order of ripening.

For all sections—Whitney, Martha, Virginia, Hyslop.

*Not recommended for sections 3 and 4.

Pears

1. Cannot be successfully grown in this section.
2. Only the hardiest varieties and then only in most favored situations.
3. Hardiest varieties moderately safe.
4. Hardy varieties escape with only occasional winter injury.

Varieties ,(In approximate order of ripening).

Tyson, Clapp's Favorite, Wilder Early, Bartlett,* Flemish Beauty, Lincoln, Howell, Seckle,* Worden Seckle,* Sheldon, Anjou, Keiffer.**

* Slightly more tender than other varieties.

** Hardiest, but poorest in quality.

Plums

1. Hansen Hybrids.
2. Native.

3-4. European and Japanese fairly successful.

Hansen hybrids—sand cherry type; Opata, Sapa, Plum type; Waneta, Toka, Tokata.

Native—De Soto, Forest Garden, Hammer, Hawkeye, Surprise,* Terry.

*Somewhat shy bearer as tree gets older.

European—Damson (for conserve) Lombard, German Prune, Italian Prune, Green Gage*.

* Not as hardy as other varieties, needs very favorable location.

Japanese—Abundance, Burbank.

Not recommended for general culture.

Cherries

1. and West three-fourths 2. (Substitute sand cherry type of Hansen plums or compass cherry-plums.)

3-4. and east fourth 2. Early Richmond, Montmorency.

Peaches

Peaches can scarcely be recommended even in the most favored sections. Occasionally seedling peaches live to produce fruit two or three years.

Elberta and Champion are among the most successful named varieties.

Some varieties not listed may be quite as satisfactory in certain areas as those suggested, but in general those recommended are most satisfactory.

Neglect of Trees Means Failure

Neglect of trees before planting and improper planting are more often the causes of losses than poor trees. Three rules should be followed in handling trees after their arrival:

1. Get the trees as soon as possible after they arrive at your station.
2. Never let the roots dry out.
3. Plant the trees just as soon after they arrive as conditions will permit.

Open the package at once and if the roots are dry it is a good plan to put them in water for a few hours. When the roots are in good condition and planting is to be done in a day or two, the plants may be kept in the package providing the material around the roots is kept moist. If planting is to be delayed several days, the trees should be removed from the package and heeled-in.

Care in Heeling-in Pays

Heeling-in is temporary planting. Select a well drained place, preferably protected from wind and sun. A better job of heeling-in will ordi-

FIG. 8.—"HEELED-IN" TREES
The best method of protecting trees between their arrival and planting time.

narily be done if the bundle is opened. Dig a trench about eighteen (18) inches deep, one side slanting at an angle of about 30 to 45 degrees. Place the roots of the trees in the trench with the trunks against the slanting side. Cover the roots with earth, working and packing it around the roots so that all parts of the root system will be in contact with the soil. Be careful not to break or bark the roots or leave openings around the stems. When trees are heeled-in in the open, the tops should slant to the south.

Plant in the Spring

Ordinarily in Wisconsin, trees should be planted as early in the spring as soil and climatic conditions will permit. While late planting may be successful, especially if the trees are dormant, the results are usually less satisfactory. Fall planting may also be successful at times, but it is too uncertain under Wisconsin conditions to be recommended.

Attention to Details Insures Successful Planting

The difficulty of placing the tree in the proper location due to having removed the stake while digging the hole can be avoided by the use of a planting board.

A simple one is made from a piece of board four to six feet long and four inches wide. Notches are cut in one side, at the center and at either end. (Fig. 9.) The side notch is placed over the stake locating the tree and stakes stuck in the ground through the notches in the ends. The board and stake may then be removed and the hole dug. Replacing the board over the pins shows the exact location for the tree.

FIG. 9.—SETTING THE TREES

Careful planting reduces losses in trees and time.

Roots Like Roomy Quarters

The roots of a young tree are reduced considerably in digging. Crowding and further reduction of the root system is to be avoided in planting trees. With favorable soil conditions, a hole 18 to 20 inches in diameter

will make it possible to meet this requirement. When the soil is heavy and compact and has not been put in the proper tilth before planting, the hole should be considerably larger.

The hole should be deep enough to permit setting the tree two to four inches deeper than it stood in the nursery. For most trees this is sufficient but with high headed trees slightly deeper planting in frequently practiced. Root grafted trees should be set deep enough so that the union of the stock and the scion is some distance below the surface.

Roots Need Little Pruning

In pruning the roots, the object should be to put them in good shape with the smallest amount of removal possible. Little attention need be given the small roots. If numerous enough to interfere in putting in the soil, the fibrous roots may be removed. The rough, splintered ends of the larger roots should be cut back to secure smooth wounds. The injured portions of badly broken or split roots should be removed. An excessively long root may be shortened.

Slanting the Tree Is Often Desirable

When the orchard is so situated that the tree will be exposed to strong winds, it is advisable to slant the trees into the prevailing wind. The amount of slant is determined by the amount of exposure, in most cases eight to ten degrees being sufficient. Another reason for slanting trees is to give the trunk greater protection during the winter so as to lessen sun scald or southwest injury. In such cases, the trees should slant southwest.

Do Not Leave Air Spaces

Air spaces around the roots result in injury to the tree. It is essential that every part of the root system be in contact with the soil. Fine soil and proper packing is necessary to give this condition. Either loosen the soil in the bottom of the hole or throw in enough fine, loose earth so that when the tree is put in place it will sink into the soil.

In filling in, use the fine soil first. After the first two or three spadefuls, it should be packed by tramping. Be careful not to crowd the tree out of place or bark the roots. Alternately put in and pack the soil to within two or three inches of the surface, then put it on loose as a mulch to prevent loss of moisture and mound it slightly around the trunk of the tree.

Watering and fertilizing newly set trees are usually of little benefit. Avoid using manure either as a fertilizer or mulch as its effects are usually injurious. If the trees are watered, use enough to nearly saturate the soil. Put it on before filling in the last few inches of soil. Keeping the top two or three inches of soil lose and fine is usually more beneficial than the application of mulches, although it is better to use a mulch if the surface of the soil is not to be kept loose.

Prune Newly Set Trees Carefully

Pruning immediately after planting is important in the formation of the head of the tree. No absolute rules can be given for pruning for this purpose, because the practice is somewhat different for different kinds of fruits and each tree of the same kind offers a different set of conditions. A few general suggestions will help determine the extent of cutting back.

In pruning one-year-old whips all that is necessary is to cut off the tops sufficently high to bring the head at the desired height after allowing about twelve inches for distribution of the branches. In older stock, it is not always possible to get the head at the right height. Sometimes it is necessary, in order to secure the desired head, to remove better branches than some which are to be left, but if those left are average then the lower heading is to be preferred.

If the tree is branched, the number of branches to be left and their position depend on the form of the top desired. In Wisconsin, a somewhat open topped tree is probably best. A newly set tree usually does not have enough branches or, if it has enough, they are not so placed as to make it possible to select as many foundation branches properly placed as are needed. This makes it practically necessary to leave the leader, the branch making the upright growth from the center of the tree, so that it may produce additional foundation branches. A leader will need to be continued one to two years to get the desired number of foundation branches and have them well placed. The branches chosen for foundation branches should be as equally distributed around the tree as possible. If unevenly distributed and the space left be wide, they should be so pruned as to throw the growth from the top bud of each of the adjoining branches into the vacant space.

With the apple, one is fortunate if he can secure three or four well developed and properly spaced foundation branches at planting. There are frequently enough branches, but they come out from the trunk too close together. Avoid as much as possible selecting branches which come out very close together. Six inches or more would be a desirable distance. but as a rule, a somewhat smaller distance will have to be accepted. Avoid as much as possible V-shaped crotches. They are weak and the branches are very likely to split under high winds or heavy loads of fruit.

There is a tendency to leave too many branches. Four are sufficient at planting time. It is better to leave even a smaller number than to use weak ones or those at least not fairly well placed or which have bad angles.

Cut Foundation Branches Back

The branches left should be cut back somewhat in order that the new branches may be forced out nearer the head of the tree and the top equalized with the reduced root system. The main branches of apples are usually left from eight to ten inches long. Twelve inches is the maximum length

FIG. 10.—PRUNE IMMEDIATELY AFTER PLANTING
A two-year-old apple tree before and after pruning.

under normal conditions, and there is little doubt that in most cases, ten inches would be better than the greater length. Weaker branches should be left proportionately longer than the strong ones. The leader should be left about two or three inches longer than the foundation branches.

Some growers prune cherries and plums very similar to apples, while others prefer to cut the branches practically to spurs, about six to eight inches long, leaving the upper branch about twelve to fifteen inches long.

Keep the Soil Cultivated

There is probably no better method of handling the soil in a young orchard than cultivation. In orchards where too much washing of the soil would occur, till a good sized area six to eight feet in diameter, around the base of the tree. Sow a cover crop July 15th to 30th or mulch the tilled area with straw or hay when the ground freezes. Protect the tree from mice by using tree protectors before putting on the mulch.

Where possible, till the entire area. If desired, grow a vegetable or other cultivated crops in the space not occupied by the roots of the trees. While from the standpoint of the trees, growing of other crops in the orchard is not beneficial, yet if properly done, it doubtless has no injurious effects, if the orchard is located on ordinary soil. The question then resolves itself into, "What is the best practice in the cropping of a young orchard?"

How much of the land may be used in orchard cropping depends upon the distance between the trees and upon the age of the orchard. In a newly planted orchard, a strip three to four feet wide along the row should be devoted entirely to the use of the trees. As the size of the trees increase from year to year, this space should be gradually increased. At all times it would be advisable to give the trees all of the soil in which the roots grow, using only that unoccupied by the trees for the crop. The mistake is frequently made of growing crops too close to the trees, often resulting in permanent injury to them.

If the young orchard is cropped, provision should be made to return at least as much plant food to the soil as is removed with the crop.

The part not occupied by the crop should be kept cultivated during the early part of the season and in July be sown to a cover crop or the trees may be mulched as for a sod orchard.

Cropping of the orchard should cease when the trees begin to produce profitable crops or when the roots occupy most of the soil area.

Sod or Tillage—Which?

There are several possible ways of handling the soils of bearing orchards. No one system is best under all conditions, therefore, before selecting the system for the orchard, a careful study should be made of the conditions under which it is to be operated. In selecting a system for use in Wisconsin, the following should be carefully considered: The

effect of the system upon the ability of the tree to withstand unfavorable winter conditions; upon the development of the tree, both immediate and ultimate; upon the amount and character of the fruit; and upon parasitism. The availability of the system to the site, and the cost of the system in relation to its advantages are other factors which should be considered.

Three favorite ways of handling the soil of the bearing farm orchard are: As a pasture; for producing hay; or for producing other farm crops. Some of these are worse than others but all are bad and should be discontinued. There are two methods which are satisfactory. These are the sod mulch and tillage supplemented by a cover crop (Tillage Cover Crop System). The latter is the most desirable where the slope of the orchard site makes it possible to use this method without too much washing of the soil. Even on sites where tillage can be used there may be times, although they will be rare, when putting the orchard in sod may be desirable. This will depend upon the performance of the trees which means that the grower will need to study his trees and modify his soil treatment according to what he learns about their growth and fruitfulness.

Some orchard sites make sod necessary. In such cases it should be clearly understood that the grass growing in the orchard should be left there. It may be cut and piled under the trees but it should not be removed from the orchard.

The tillage cover-crop system as practiced in Wisconsin consists in keeping the orchard under cultivation during the first part of the growing season, then sowing a crop which remains in the ground during the winter.

The orchard is plowed or disced in the spring to turn under the cover-crop. The plowing need not be as deep as if a field crop were to be grown upon it. As the base of the tree is approached, the plow should be run more shallow. It is more convenient to use one horse in turning the last two or three furrows next to the tree, as this permits getting much closer to the tree without so much danger of injury. The use of a short whiffletree with leather ends or with the ends covered with burlap protects the trees from being barked. All the soil possible should be turned and that which cannot be reached conveniently with the plow should be stirred later on with the cultivator. On lighter soils, when there is little of the cover-crop left at the time of cultivation, the cut-away or disc harrow may be substituted for the plow.

After plowing, the soil should be put in fine tilth. The ideal condition is to have a mulch of fine soil two or three inches in depth over the entire orchard. Harrowing after each rain and at least every two weeks maintains the soil mulch, conserving the moisture and keeping down the weeds.

Cover Crops Help In Several Ways

Several advantages may be gained by the use of a cover-crop. It is of great value in lessening the danger of winter injury in that it forms a mulch and helps hold the snow, thereby protecting the roots and lessening

FIG. 11.—A WELL TILLED ORCHARD

Later on a cover crop will be sown for protection during the winter.

the drying out of the soil. It may also influence the maturity of the growth of the season, lessening to a degree the danger of top injury. It benefits the soil by adding organic matter, holds plant foods which might leach from the soil, prevents erosion, and if a leguminous crop, may increase the nitrogen content of the soil.

The time of sowing the cover-crop in Wisconsin is usually between July 10 and August 1. The soil should be fitted the same as for sowing ordinary field crops. The amount of seed to be sown for the various crops is somewhat in excess of that used in ordinary field culture.

A cover crop is food supplying or non-food supplying; hardy if it lives through the winter, tender, if it does not. Some hardy cover-crops are less efficient in holding snow on the orchard than some of the tender crops. In selecting a cover-crop, its ability to hold snow should be considered. Hairy vetch is about the only hardy food-supplying cover used in Wisconsin. Field peas and soybeans are the best of the food supplying tender crops; barley, oats and millet are the most used non-food supplying tender crops and rye the best non-food supplying hardy. Buckwheat, a non-food supplying tender crop, is frequently used but it does not stand up very well during the winter. It is advisable at times to combine two or more crops in producing a cover. Canada peas and oats are a common combination.

Feed the Trees

There is no other factor of orchard management about which less definite information can be given than orchard fertilization. Orchard soils differ so much in their composition and treatment that no hard and fast rule can be made. The grower must determine for himself what is the

FIG. 12.—OATS A GOOD COVER CROP

A growth like this reduces the danger of winter injury.

limiting factor in his production and then bring that up to normal. The difficulty may not be a deficiency in any element of plant food, but one of cultivation or lack of vegetable matter in the soil.

On ordinary soils and unless other crops are being grown, an orchard will not need fertilization until the bearing age is reached. If other crops are grown the equivalent of the plant foods removed should be returned to the soil. Heavily bearing orchards on lighter soils will usually need fertilizers sooner than those on heavier soils. This applies not only to the initial application, but as the orchard grows the lighter soils will require heavier and more frequent applications. The food supply of orchards on heavy soils in more dependent upon keeping the soil in good tilth so that the plant food which is usually quite abundant may become available.

With the average grower, the application of a nitrogenous fertilizer, the incorporation of vegetable matter into the soil, and keeping up a good tilth, are undoubtedly the operations of most concern. More often than is usually thought lack of nitrogen is a limiting factor in fruit production. Its deficiency is indicated by short annual growths, and an unhealthy or yellowish green appearance of the leaves. On most farm orchards an annual application of nitrate of soda or sulphate of ammonia will be beneficial. Depending upon the size of the tree, two to four pounds per tree may be safely used. It should be put on two or three weeks in advance of blossoming. In using nitrogen, however, care must be taken not to apply too much as this would tend to produce excessive wood growth and decrease the color of the fruit.

Stable manure is one of the most commonly used orchard fertilizers. It chiefly supplies nitrogen and should be supplemented by other materials if it is to be used most economically. One of the chief advantages of manure is that it supplies considerable vegetable matter to the soil which is even more important than the plant food it furnishes. No matter how much plant food is in the soil, the tree will be unable to profit by it unless the soil also contains organic matter. The first thing to do in the orchard which seems to be suffering from lack of food, is to see that the soil is well supplied with organic matter. Good cultivation is also important for otherwise the best conditions are not given for rendering available the plant food already in the soil. Good tillage, should, therefore, precede the application of fertilizers.

If the orchard shows indications of lack of plant food, supply vegetable matter by growing a cover crop or applying barnyard manure, and incorporate it into the soil by thorough tillage; then if the orchard does not respond, use fertilizers.

FIG. 13.—UNPRUNED AND PRUNED TREES

Neglect of pruning results in inferior fruit. The top of the tree should be fairly open to secure the best results.

Proper Pruning Gives Better Crops

Pruning, although essential to rational orchard management, is one of the most neglected practices. The little that is done is usually haphazard, spasmodic, and not infrequently more injurious than beneficial. The bad effects of neglected pruning, especially of young trees, can never be corrected so as to give as good a tree as thought the work had been done at the right time.

The best pruning has a definite purpose and is founded on right principles, a careful study of local conditions, and the peculiarities of the kind of fruit and of the variety grown. If the tree is properly pruned before bearing, pruning after it comes into bearing is a much less troublesome problem.

Pruning during the early stages of a tree's development has for its primary object the formation of an ideal fruit bearing area. Making up this ideal are such factors as: Proper branching, keeping the top open, encouraging the production of fruit spurs, correcting defects of growth, and keeping the head down so that spraying and harvesting will be facilitated. It should not be a matter of merely clipping out a branch here or there, but each tree should be carefully studied as to its individual characteristics and then pruned accordingly.

Dormant Period Best Time To Prune

Pruning is not confined to distinct periods or seasons. Some of the best growers carry heavy pocket knives and whenever they see an undesirable branch, remove it. As a rule, however, pruning is performed during the dormant period and called winter pruning. Prune any time after the leaves drop in the fall and before growth starts in the spring. Plan to prune early, then there is less danger of its being hurried or entirely neglected because of the rush of spring work.

Pruning the Young Tree

The pruning during the season following the selection of the foundation branches consists, primarily, in removing the superfluous twigs which have been formed on the main branches chosen at the first pruning, in shortening the growth, and in selecting additional foundation branches. The tendency to leave too many branches the second year is almost as great as at the first pruning. One or two strong twigs to each foundation branch, depending upon the number of main branches, will be sufficient to fill in the head. It is best to remove branches having a tendency to grow into the center the second season, as there will be sufficient time to thicken the top later.

The new foundation branches should be cut back from fifteen to eighteen inches. The secondary branches arising from the first foundation branches should be left from two to four inches longer. Varieties with a weak, slender growing habit need to be cut back more than those with strong, heavy branches. The leader should be left if additional foundation branches are desired. It should be two or three inches longer than the foundation branches. When not needed to provide for more foundation branches, the leader should be suppressed. This is ordinarily done by cutting out the leader or leading branch, cutting back to the topmost lateral produced by the leader which was left the previous season.

If the tree was a whip when planted, pruning the next season will be similar to that for a two-year-old tree at planting except that the founda-

tion branches chosen should not be cut back so severely. In pruning trees of this type, the foundation branches should be left from fifteen to eighteen inches long.

Precautions should be taken at the pruning the season after selecting the first foundation branches to correct any defects in the direction which the branches are taking. If there are open spaces being left in the top, prune so the top buds of branches on either side will be on the side next to the opening. If the branches have a tendency to grow too upright, cut back so that the top bud will be on the lower or outer side; if they spread

FIG. 14.—SUPPRESSION OF LEADER

Practically all of the main branches are of the same size. The leader should be definitely suppressed at "A" or even lower. Note the desirable development of lateral branches (B, B). This is a tree "full of brush," but yet rather typical of Transparent. The top is relatively flat and open to the light.

too much, have the bud on the upper or inner side. Pruning to a particular bud is of great importance in the early pruning of a tree if the best head is to be secured. Many growers pay too little attention to this matter when "heading-in."

Choose, if possible, a good strong bud in the position in which desired. In cutting back, make the cut just above this bud. A strong knife will be found best for this purpose.

Do Less Pruning the Third Year

If the pruning during the first two years has been properly done, that for the third year will be proportionately less. The frame work of the tree should be formed by this time so that pruning will consist almost entirely in removing superfluous shoots and cutting back the new growth which is to be left. Branches which rub or are inclined to form bad crotches should be removed. Too many branches should not be allowed to grow into the center of the tree as it is desirable in Wisconsin to keep the top quite open to permit the entrance of sunlight and allow the air to circulate through the tops. The ends of long seasonal growths may be cut back somewhat but proportionally less than in previous prunings. Pruning for subsequent years with bearing trees will follow closely that outlined for the third season except that cutting back will be less pronounced as the tree gets older.

Trees Need Pruning Every Year

Pruning should be done every year. The results will be more satisfactory and less time will be required than when the growth accumulates for a number of years.

Pruning of the bearing tree has for its primary purposes, the removal of sucker growths, keeping the top fairly open and as low as practical, the production of new fruiting wood and the maintenance in a vigorous condition as long as possible older fruiting wood. New growths tending to fill the center and water sprouts (suckers), unless needed to fill vacancies, should be promptly removed.

The usual practice of shearing back the ends of all the longer terminal growths should be avoided because this causes bushiness of the top. Do little cutting back of terminals but keep the head of the tree down by selecting a side shoot lower down on the two-year-old wood and remove the end of the second year's growth with its new shoots.

In pruning neglected trees, the same general practices should be followed. The first thing that the grower should realize is that this operation usually requires more than one year. As a rule the top of a neglected tree is a mass of growths, a large number of which should be removed or cut back. However, if this is done in a single season, the tree is forced into a heavy top growth and conditions are almost as bad at the end of the season as they were before.

In pruning such a tree, the first thing is to cut out the dead wood and then remove the water sprouts or suckers that have arisen from the main branches. If these are not numerous, the more seriously interfering branches will next receive attention. On most trees some heading back may be done. Don't "dehorn" the tree but gradually work down the head by cutting back the tallest branches to a good lateral lower down. Pruning the second season consists in removing the new growth of water sprouts and further opening up the top if desirable. In thinning out a neglected tree numerous small cuts made throughout the top will give much better results than the removal of large branches leaving large open spaces in the top. A fairly safe rule to follow in pruning is to make as few large cuts as possible. If the tree has been properly pruned from planting, large cuts will be necessary only in unusual cases.

FIG. 15.—CUT BACK TO A STRONG LATERAL

Make cuts at the arrows. This method keeps the top down and prevents bushiness.

Pruning Wounds Are Danger Points

Neglect or improper making of wounds frequently results in serious injury or even premature destruction of the tree. In pruning young trees, or where thorough annual pruning is practiced, a strong knife and small hand shears are all the tools that are necessary until the tree reaches the height where a pole pruner will be needed for heading back. On newly set trees, a strong knife is more desirable than hand shears, because the branches can be cut off nearer the trunk. By cutting from below toward the trunk or branch to which they are attached, quite large branches may be removed without difficulty. When the branch is nearly severed be careful that the knife does not come through suddenly and injure other branches which are to be left. In removing branches with the pruning shears, put the blade next to the trunk or main branch and press the branch to be removed away from the blade.

To avoid splitting large branches, double sawings are usually desirable. This consists in cutting the branch off some little distance from the trunk or main branch, and then removing the stub. In the first sawing, it is well to saw one-third to one-half through the branch from the under side, then finish the sawing from above. The upper cut should be made

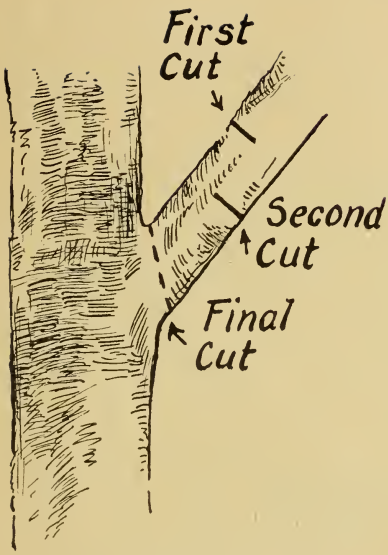

FIG. 16.—REMOVING LARGE BRANCHES

Splitting down often occurs in removing large branches. There will be little chance for trouble if the branches are cut away as indicated in this drawing.

slightly farther from the trunk than the under. For removing large branches, a pruning saw is desirable. There are a number of forms on the market. Those shown in Figure 18 are desirable. An axe should never be used.

All branches should be cut off near the branch or trunk to which they are attached, the cut being made just beyond the collar and nearly parallel to the part from which the branch is removed. Avoid stubs because they seldom heal over and therefore become sources of infection and decay. Have the surface of the wound smooth. Rough or splintered wounds heal slowly; and the longer the time required in healing, the greater the danger from infection. If the bark has been torn, the uneven edges should be cut back to sound bark. A sharp knife, pruning shears, or saw usually make good wounds. Always avoid dull tools.

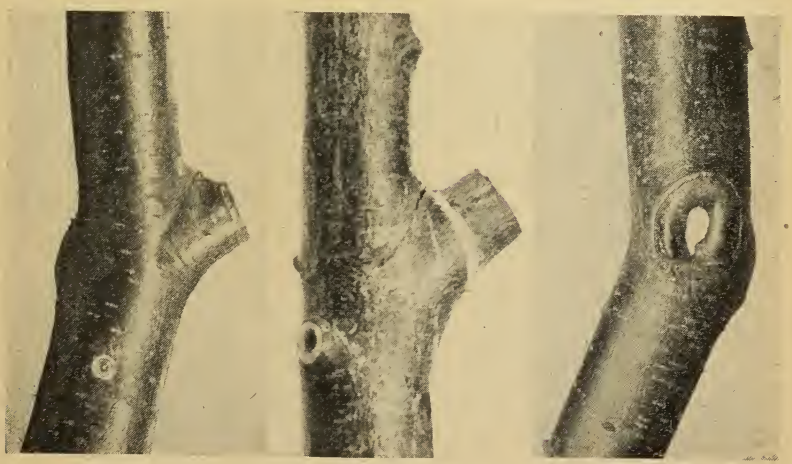

FIG. 17.—MAKE WOUNDS CAREFULLY

(Left)—Wound improperly made. Do not leave stubs. (Center)—The proper place to make the cut. (Right)—The properly made wound heals more rapidly.

Wounds an inch or more in diameter should be treated with a protective material to insure good healing. The material used will not hasten the healing only as it prevents unfavorable external conditions. An adhesive material that will prevent checking, keep out moisture and fungi,

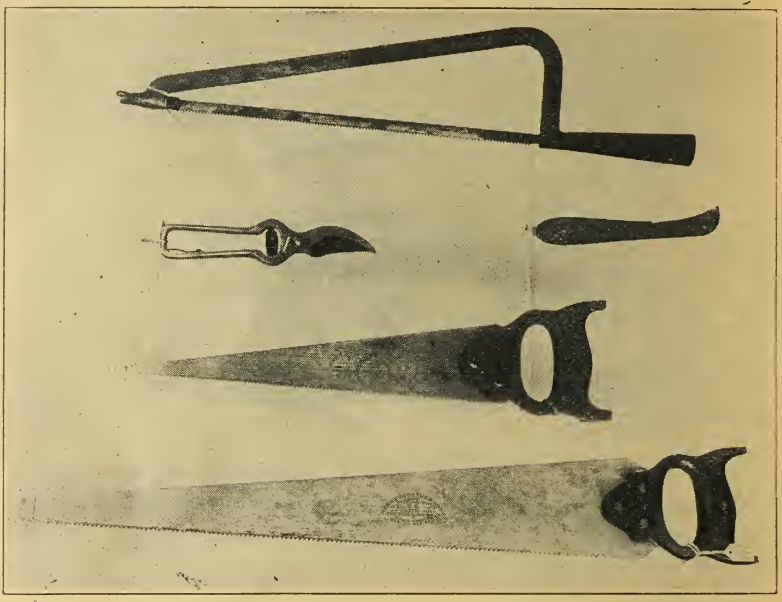

FIG. 18.—GOOD WOUNDS REQUIRE GOOD TOOLS

A good knife, shears and a pruning saw are not only convenient but practically necessary for good work.

and not injure the cambium (just inside the inner bark) is desirable. This combination is hard to get. Selby* recommends gas tar or asphaltum. White lead is commonly used but it has a tendency to dry out and permit checking. If used, it should be applied thick. A second application may be made if checking occurs.

Spraying Is Necessary for Good Fruit

The two most common mistakes in spraying the home orchard are failure to spray at the proper time and lack of thorough work. Both proper time and thoroughness are essential to success. Spraying is preventive. Spraying after the "worms" are in the apples will not give "wormless" fruit. Apple fruits or foliage which are not entirely covered with spray will be open to the attacks of the apple scab fungus. The same is true of other fruits. Thorough and timely spraying, therefore, is the only spraying worth while. Because the pests which commonly at-

*Ohio Agr. Expt. Sta. Cir. 126, "Dressings for Pruning Wounds of Trees."

tack fruits to a serious extent are comparatively few in number, spraying operations can be largely confined to more or less definite times. Directions as to the materials to be used and the time of their application form what is popularly known as a "spraying program." Even with the spraying program, the grower must study his conditions in order to spray most successfully.

In giving a program for spraying common fruits, it must be clearly understood that there are certain pests which are not controlled by the application of the materials recommended. Some pests demand special treatment.

FIG 19.—BLIGHTED APPLE TWIG

Blight is very severe on young, rapidly growing wood; the leaves becoming black.

How to Control Apple Pests

Common pests of the apple in Wisconsin are codling moth, plant lice (aphis), curculio, scale insects, apple scab and fire blight.

Fire blight is usually first noted by the leaves at the tips of the branches turning a reddish brown. This discoloration extends downward along the branches as the season advances. A close examination will reveal a blackened, shrunken, and frequently shriveled appearance of the bark. When peeled off, the inner portions will be found to be discolored. This brown discoloration will often extend beyond a point where the bark shows any sign of the disease on the outside. It may also appear as sunken or "cankered" areas on the trunk or larger branches.

The disease is most prevalent on rapidly growing trees although varieties differ as to resistance to attack. There is no spray treatment for the control of fire blight. The only treatment is to cut out the infected twigs six to eight inches below any sign of the disease and burn. Cut cankered areas back to healthy bark. Disinfect the wound with corrosive sublimate and mercuric cyanide, one part to each one thousand of water and then treat as for wounds in pruning. It is best to disinfect the knife after removing the infected part by dipping it in the solution. The material is a deadly poison requiring care in handling.

Spray Occasionally for Scale

Quite frequently in home orchards, oyster shell scale becomes so numerous as to cause considerable damage. Spray with lime sulfur shortly before growth starts. Use 5 gallons commercial lime sulfur in 40 gallons of water, which is known as "winter strength lime sulfur." This spray is needed only when the scale become fairly numerous. If it is desired to combine this spray with the one following, delay the application until the buds show green. In some parts of the state San Jose scale also needs attention. Spray shortly before growth starts with scalecide 1 part to 12 of water or with other miscible oils.

Use "Nicotine Sulfate" Against Plant Lice

While plant lice are usually present, they seldom become so injurious under Wisconsin conditions as to make control measures necessary. If spraying is desirable, apply "nicotine sulfate," ½ pint to 50 gallons of water, to which should be added 2 pounds of soap in solution. One half pound of casine spreader may be substituted for the soap. Apply just as the buds begin to show green.

Annual Sprays Necessary

While spraying for scale and plant lice may not be necessary in a particular season, the control of apple scab and the codling moth (apple worm) demands that spraying be done each season if pest free fruit is to be obtained.

Use 5 quarts lime sulfur and 1 pound powdered arsenate of lead in 50 gallons of water.

1. "Pink Spray"—Just before the blossom buds open. (If leaf rollers are numerous use 3 pounds of arsenate of lead.)

Do Not Spray Fruit Trees With Poison When Many of the Blossoms Are Open

2. "Calyx Spray." As soon as most of the petals have fallen and before the calyx cups close.
3. Fifteen to eighteen days after second spray.
4. About August 15-20 on late varieties.

In addition to these four applications, the "pre-pink spray" is strongly recommended because of its great benefit in controlling apple scab. Apply when leaves of opening buds are about the size of a squirrel's ear. Use regular spray.

In the home orchard, the same spray program may be used for pears. The cherry and plum should receive two applications soon after the blos-

soms are off. These applications can usually be made at the same time as applications (1) and (2) for the apple. An additional application should be put on cherries soon after the fruit is harvested. On European and Japanese plums, an application made when the plums begin to change color will help to control brown rot.

FIG. 20.—FOUR PESTS OF APPLES

(Top row)—Oyster shell scale (greatly enlarged) on the right; curculio on the left. (Bottom row)—Scab on the right; codling moth on the left.

How Much Spray?

For an apple tree the average amount of spray for one application is as follows:

Age in years.....	10	12	15	20	25
Gallons of spray.....	2	2½	3-4	4-5	5-6

When preparing sprays in small quantities, it is very convenient to have a postal scale and a measuring spoon such as is used in the kitchen. It is much more satisfactory to weigh the dry materials. The following formulas give spray materials of approximately the same strength as those used in commercial orchards:

Lime sulfur (liquid) (winter strength) 1 pint to 1 gallon water.

Lime sulfur (liquid) (summer strength) 1 pint to 5 gallons water.

Lime sulfur (dry) (summer strength) 1 ounce (2 level tablespoonfuls) to 1 gallon water.

Arsenate of Lead: To make a spray equivalent to 1 pound to 50 gallons of water, use 1 ounce (6 level tablespoonfuls) to 3 gallons of water.

Good Spraying Necessitates Good Equipment

Time and money are lost in attempting to spray with poor equipment. First class machinery in good working order and mixing equipment adequate for the amount of material to be handled and designed to facilitate the preparation of materials and the filling of spray tanks are essential to economical and efficient work.

FIG. 21.—A POWER SPRAYER

A quick, economical and efficient outfit.

The mixing equipment will vary with the amount of spraying to be done and the materials to be used. Convenient water supply is a time saver in spraying. A creek or pond in proximity to the orchard saves much time in pumping or hauling water. It is important, however, that the water be free from grit.

Pump Depends on Size of Orchard

The character of the pump depends largely upon the size of the orchard to be sprayed. A gasoline pump is most desirable. Such a pump is designed to handle large amounts of material and furnish sufficient pressure to produce an ideal spray. A good gasoline sprayer should maintain a pressure of 200 to 300 pounds, be light in proportion to power generated, be compact, have working parts easily accessible, have a good device for controlling pressure and an engine preferably fitted with force feed.

What Is a Spray Ring?

Home orchards are as a rule too small to make it economical to purchase a power sprayer so that, in a number of instances, farm orchardists have united in their orchard spraying. The organization, composed of

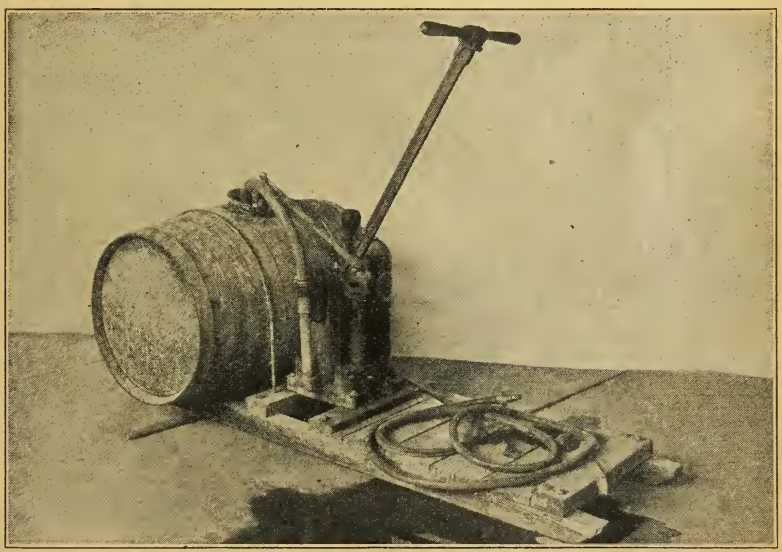

FIG. 22.—A GOOD TYPE OF SPRAYER FOR SMALL ORCHARDS
It will do good work when carefully and properly used.

from six to twelve farmers whose farms are close together, is known as a "spray ring." They purchase a power machine suitable for their needs, the cost ranging from $200 to $400. Each farmer owns an equal share. A member of the "ring" acts as operator and is paid for his work. Other officers are named if desired. The operator buys spraying materials; sprays the orchards of members at the proper time and in the right way and distributes the cost of spraying among members of the "ring" on the basis of time and materials used in spraying each orchard.

The following are the principal advantages gained through the organization: It makes possible the owning of a power sprayer at an individual cost less than that of a hand outfit. It reduces the price of spray materials, as they can be secured in large quantities at much better prices than when purchased in small amounts by the individual farmer. It results in more efficient spraying because of better equipment and more experienced operator. It costs less because the time and material used are reduced.

A Barrel Pump May Be Used

When only one home orchard is to be sprayed with a pump, the horizontal type of hand pump is usually most satisfactory. It is built with two cylinders which makes it possible to maintain a fairly satisfactory pressure. They are much more easily operated than the old style vertical barrel pump. Some of them are not fitted with agitators. If this is the case, agitation must be provided as most orchard sprays require agitation for good results.

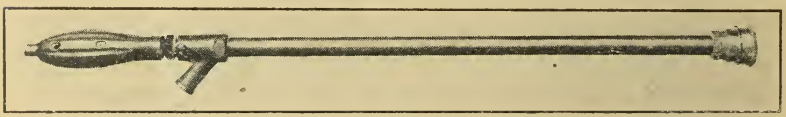

FIG. 23.—A SPRAY "GUN"

More rapid, but efficient if properly used.

It Pays to Use Good Hose

A good quality spray hose costs less in the end as it is more durable than the common garden hose. One-half inch hose is sufficiently large. If but one lead is used, it should be at least 25 feet long. If two leads are used, it is well to have different lengths. If the work is to be done from the ground, 20 to 25 feet is a minimum length.

Hose should be fitted with couplings with long shanks and good hose clamps. Two clamps to a coupling are usually preferred. With the ordinary type of hose coupling there is continual trouble from having the hose blow off. On a power machine it is advisable to have a shut-off between the pump and hose.

Don't Miss the Tops

An extension rod or spray gun is necessary in spraying trees over seven or eight feet high. The best type of spray rod is a bamboo pole through the center of which runs a brass tube. These rods may be had in lengths to suit the work to be done. A ten foot rod is usually preferred. There should be a "shut-off" or "stopcock" between the hose and the spray rod which should be non-leakable and close with a half turn.

The spray gun is very much more convenient than the spray rod and does faster work. It can be used efficently, however, only when a high pressure of 200 pounds or over is maintained.

Selection of Nozzle Important

Two general types of nozzles are used in orchard spraying. They may be characterized as the Bordeaux and eddy chamber types. The Bordeaux, which is not extensively used in the East, produces its spray by forcing the material through a small aperture against a smooth surface. The character of the spray is regulated by the pressure and the angle at which it strikes the obstructing surface. This nozzle has great driving power and is extensively used in the West for calyx spray of apples and pears.

The eddy chamber type of nozzle produces the spray by forcing the liquid to rotate rapidly as it is expelled through a small aperture at high pressure which breaks it up into a mist-like form. There are various devices for producing the whirling motion. The character of the spray

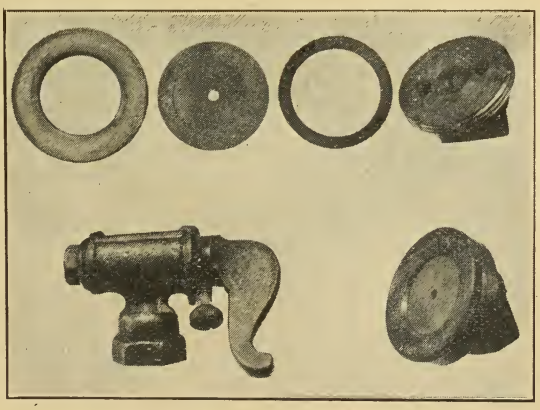

FIG. 24.—CHOOSE SPRAY NOZZLES CAREFULLY

Spray nozzles differ in their adaptability. Care in selecting the right nozzle will result in economy and in effectiveness in spraying. (Bottom)—Left—Bordeaux nozzle. Right—Angle disc nozzle. (Top)—Parts of the disc nozzle.

is regulated to a greater or lesser extent by the pressure, the size of the aperture and the relation of the openings in the whirling device to the aperture. This is the type of nozzle used extensively in the East.

It is desirable to have the opening of the nozzle at an angle to the rod as it greatly facilitates putting on the material. Some nozzles known as angle nozzles are so constructed as to accomplish this. Unless an angle nozzle is used, an angle connection is imperative for efficient work.

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